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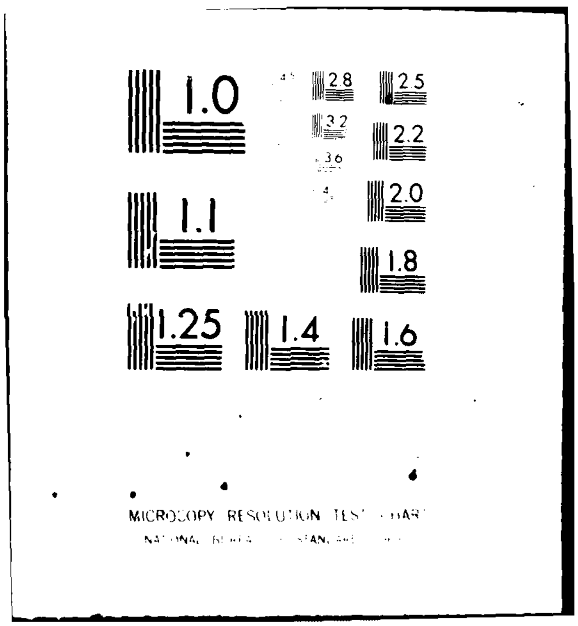
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SSA-117 December, 1978

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SURVEY OF THE CURRENT STATUS
OF THE LWR AND PROJECTED IMPROVEMENTS

Prepared For

U.S. ARMS CONTROL AND DISARMAMENT AGENCY

Prepared By

Southern Science Applications, Inc.
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Dunedin, Florida 33528

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It is concluded that an achieveable saving of about 8% is possible in the PWR cycle solely by extending fuel burnup (perhaps slightly larger in BWRs) and another 8% by decreased reload batch size. This is a naturally occurring evolution which government funding may only accelerate. A further improvement by altering the fuel cycle (fast shuffle and/or increased number of core zones) may be realized (at higher risk) by more extensive and expensive design modifications. Alternate fuel cycles could substantially increase the savings, but at considerable expense and yet higher risk.

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AC8NC109

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I. INTRODUCTION

This study is prepared under Contract No. AC8NC109 (Task II) to provide a basis for projecting and substantiating near and intermediate term improvements in the Light Water Reactor (LWR) resource utilization. The evaluation is described in three parts:

- History of LWR Fuel Utilization. A brief history of LWR fuel burnup experience, with interpretation/extrapolation to the year 2000.

- Potential Improvements. Survey of potential savings in uranium resources from increased fuel burnup to an achievable target value, and an assessment of state-of-the-art capability of reaching that objective. In addition, identification of other potential design/fuel management improvements and attendant potential gains and uncertainties.

- Alternate Nuclear Technologies. Estimation of savings in uranium resources by utilizing the U/Th cycle and Pu/U recycle, and an assessment of risk elements, probable costs, and industry willingness to support implementation on a commercial scale.

It is concluded that an achievable saving of about 8% is possible in the PWR cycle solely by extending fuel burnup (perhaps slightly larger in BWRs) and another 8% by decreased reload batch size. This is a naturally occurring evolution which government funding may only accelerate. A further improvement by altering the fuel cycle (fast shuffle and/or increased number of core zones) may be realized (at higher risk) by more extensive and expensive design modifications. Alternate fuel cycles could substantially increase the savings, but at considerable expense and yet higher risk.

II. HISTORY OF LWR FUEL UTILIZATION IN ACHIEVED BURNUP

One measure of the nuclear fuel utilization is the achieved burnup of fissile material placed in the power reactor, generally expressed as the energy released in megawatt days of thermal energy produced per metric ton of uranium metal supplied to the reactor.

In order to obtain consistent data for this history, burnup data was obtained from the Nuclear Assurance Corporation for evaluation. These data, included in this report as Appendix A, include:

- Reactor name;
- fuel discharge batch designation;
- fuel discharge data; and
- fuel batch average discharge burnup (Mwd/mtU).

In the analyses of this data, distinction was made by reactor vendors: All batches from a specific reactor were averaged by discharge data. Trends of increased burnup as a function of experience, as indicated by location in a time frame, were determined using linear regression techniques. Considerable scatter of data points is obvious and analysis of the Babcock & Wilcox and Combustion Engineering reactors was not included since correlation of data was not as good as that found in the cases of the longer histories of the General Electric and Westinghouse reactors. The boiling water reactors and pressurized water reactors show similar trends of increased burnup with time but start from a different base. Those trends are shown in Figs. 1 and 2, and a comparison between the two types of reactors is shown in Fig. 3. Some individual reactor histories which cover periods of seven to eighteen years are of interest and are included as Figs. 4 through 9, inclusive.

Current achieved burnups and rate of burnup increase are included in Table I. Based upon these historical data, linear extrapolation yields projected fuel burnups to the year 2000, also listed in Table I. The projected burnup in the year 2000 is a 22-year extrapolation based on 18 years of data and is subject to considerable uncertainty. However, burnups in excess of 50,000 Mwd/mtU for pressurized water reactors, and 41,000 Mwd/mtU for boiling

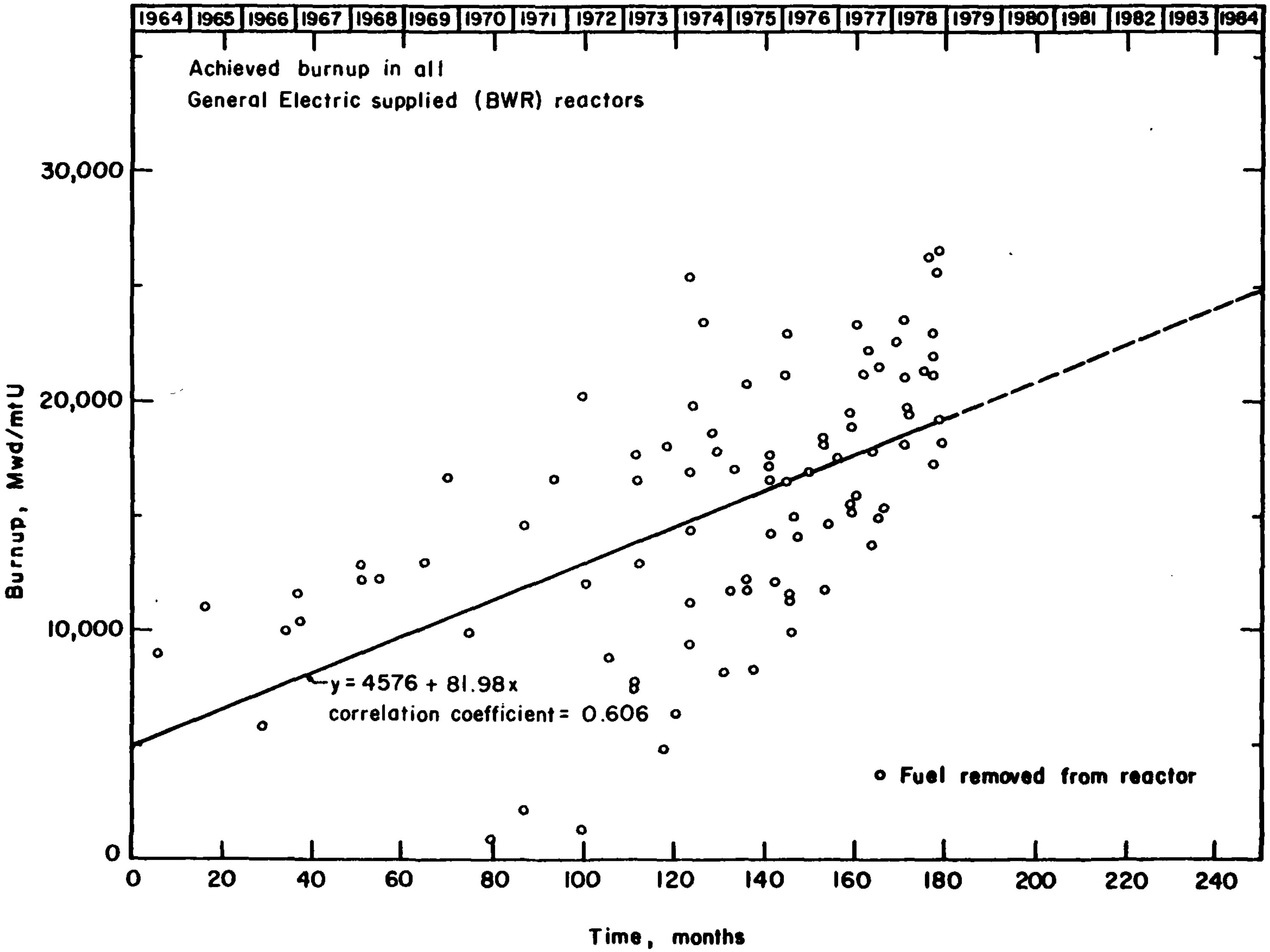

Fig. 1. History of discharge fuel burnup achieved in BWR.

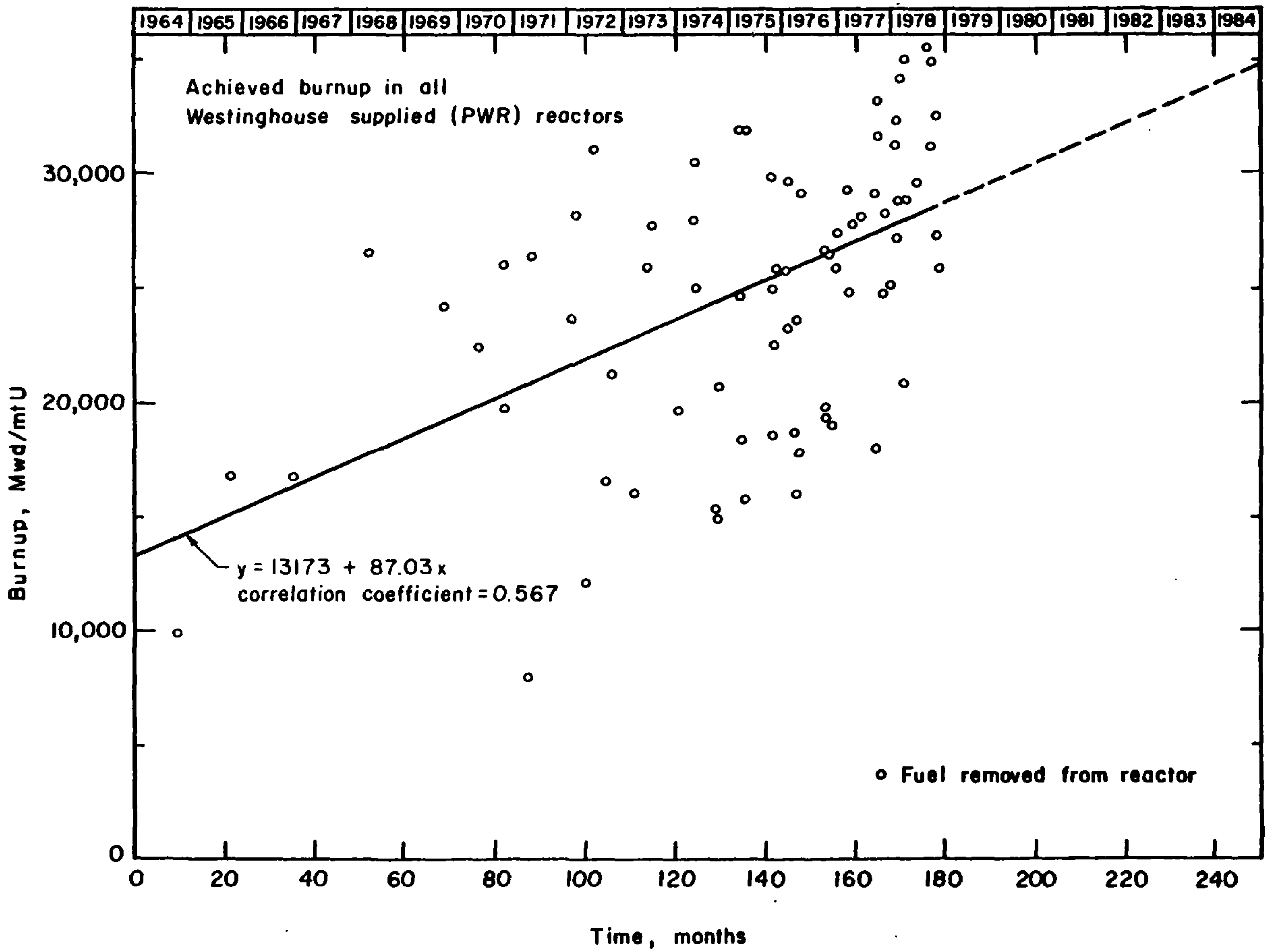

Fig. 2. History of discharge fuel burnup achieved in Westinghouse PWRs.

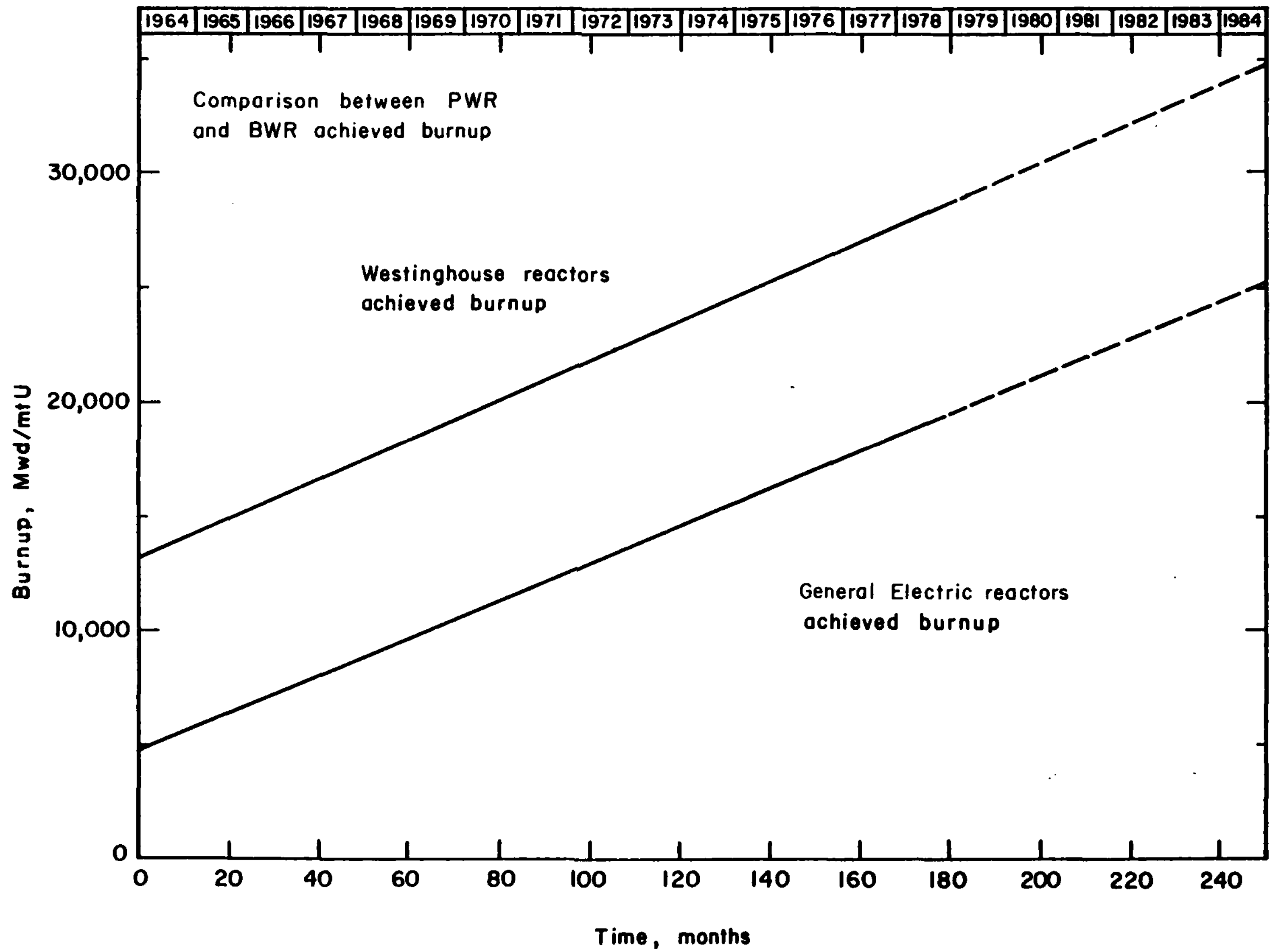

Fig. 3. History of average fuel burnup achieved at discharge.

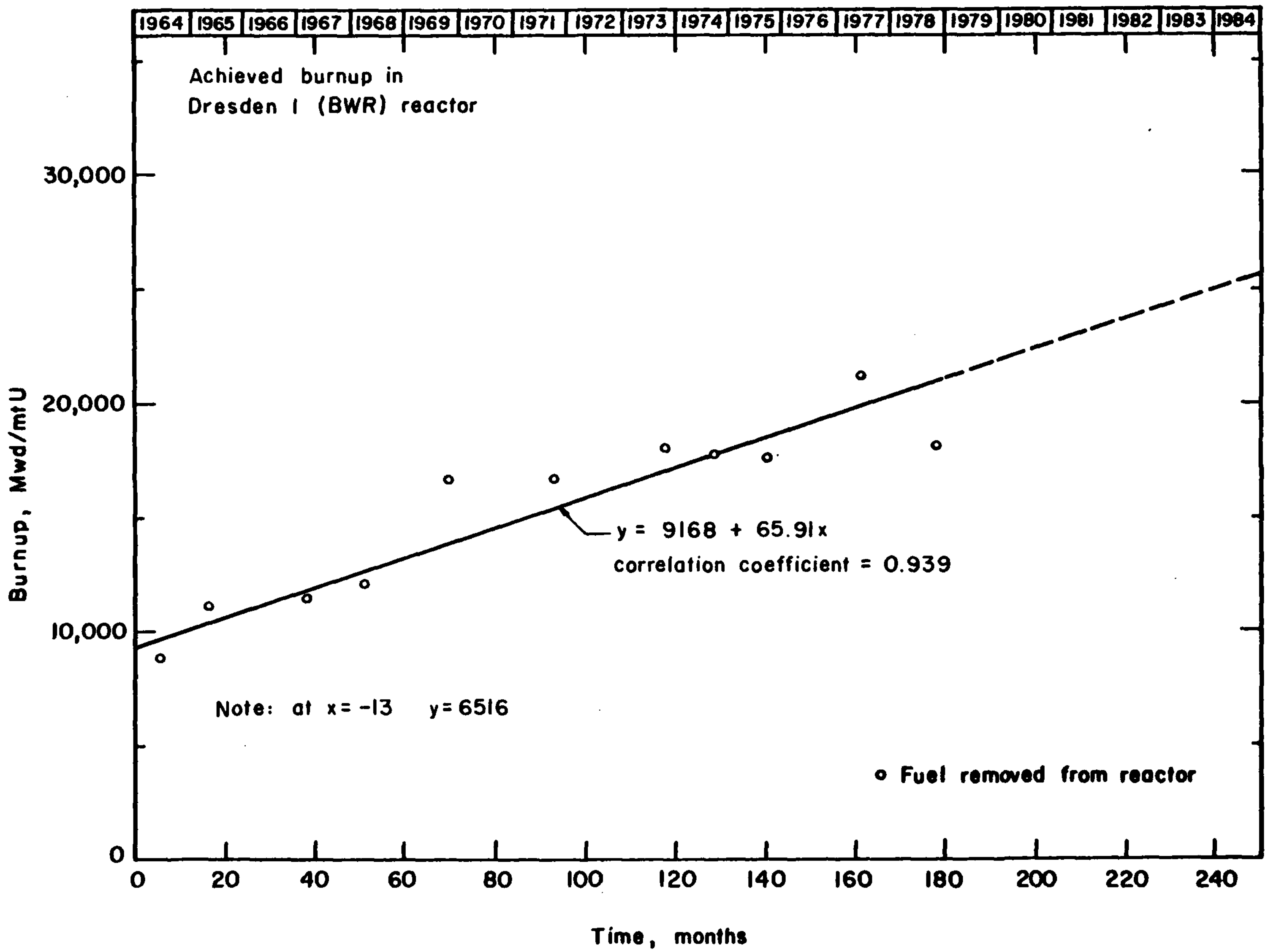

Fig. 4. History of discharge fuel burnup achieved in the Dresden 1 reactor.

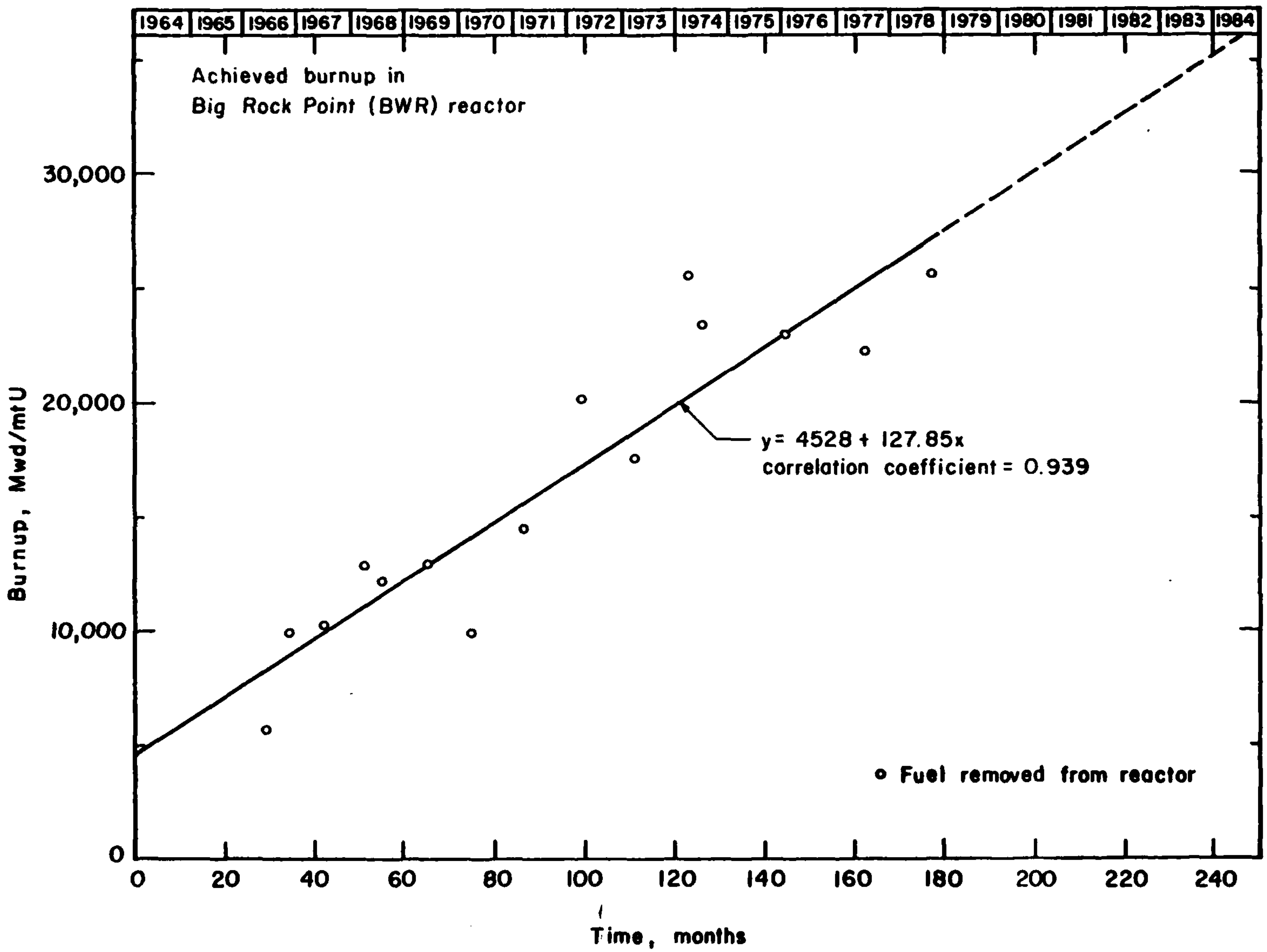

Fig. 5. History of discharge fuel burnup achieved in the Big Rock Point reactor.

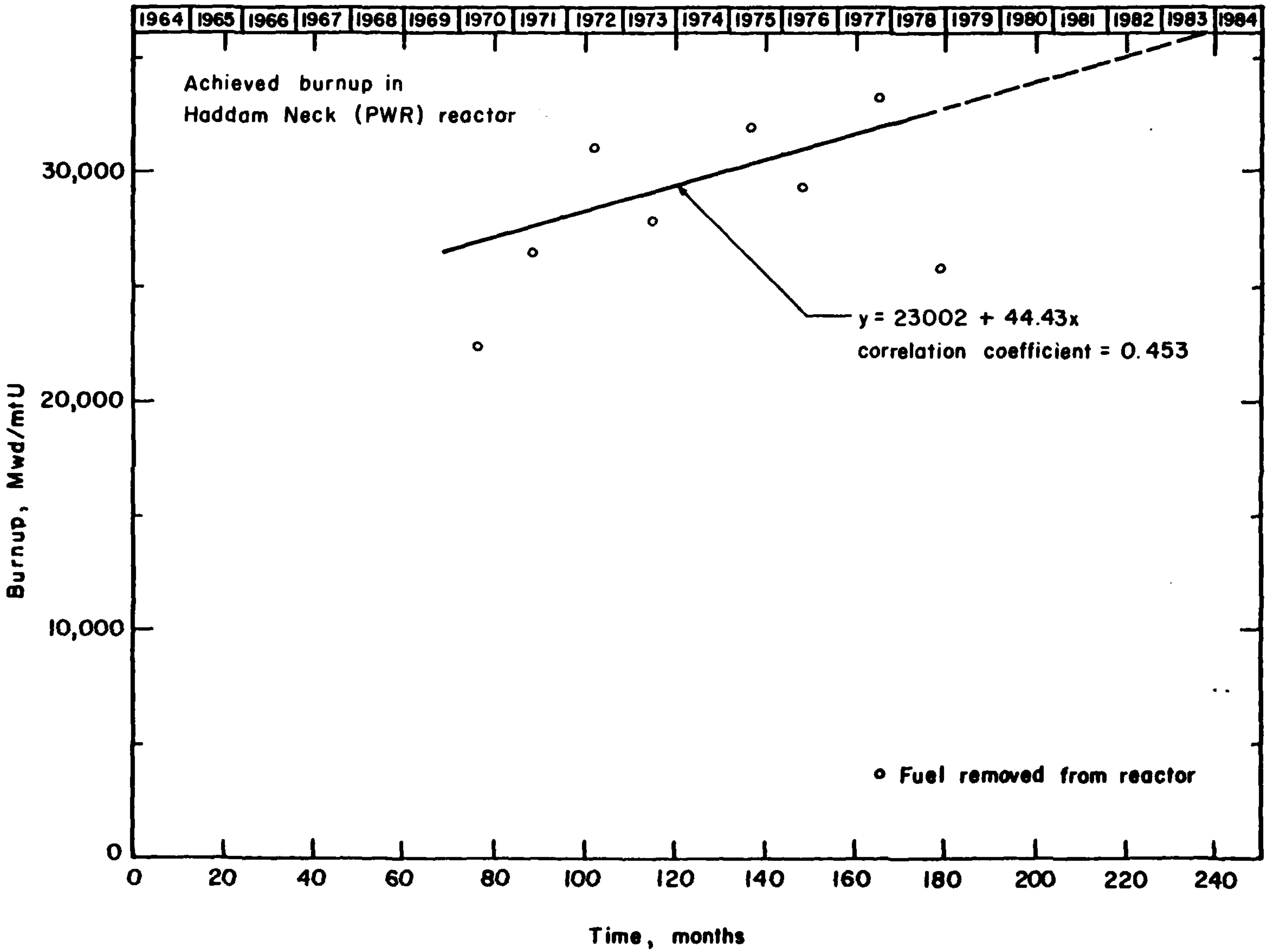

Fig. 6. History of discharge fuel burnup achieved in the Haddam Neck reactor.

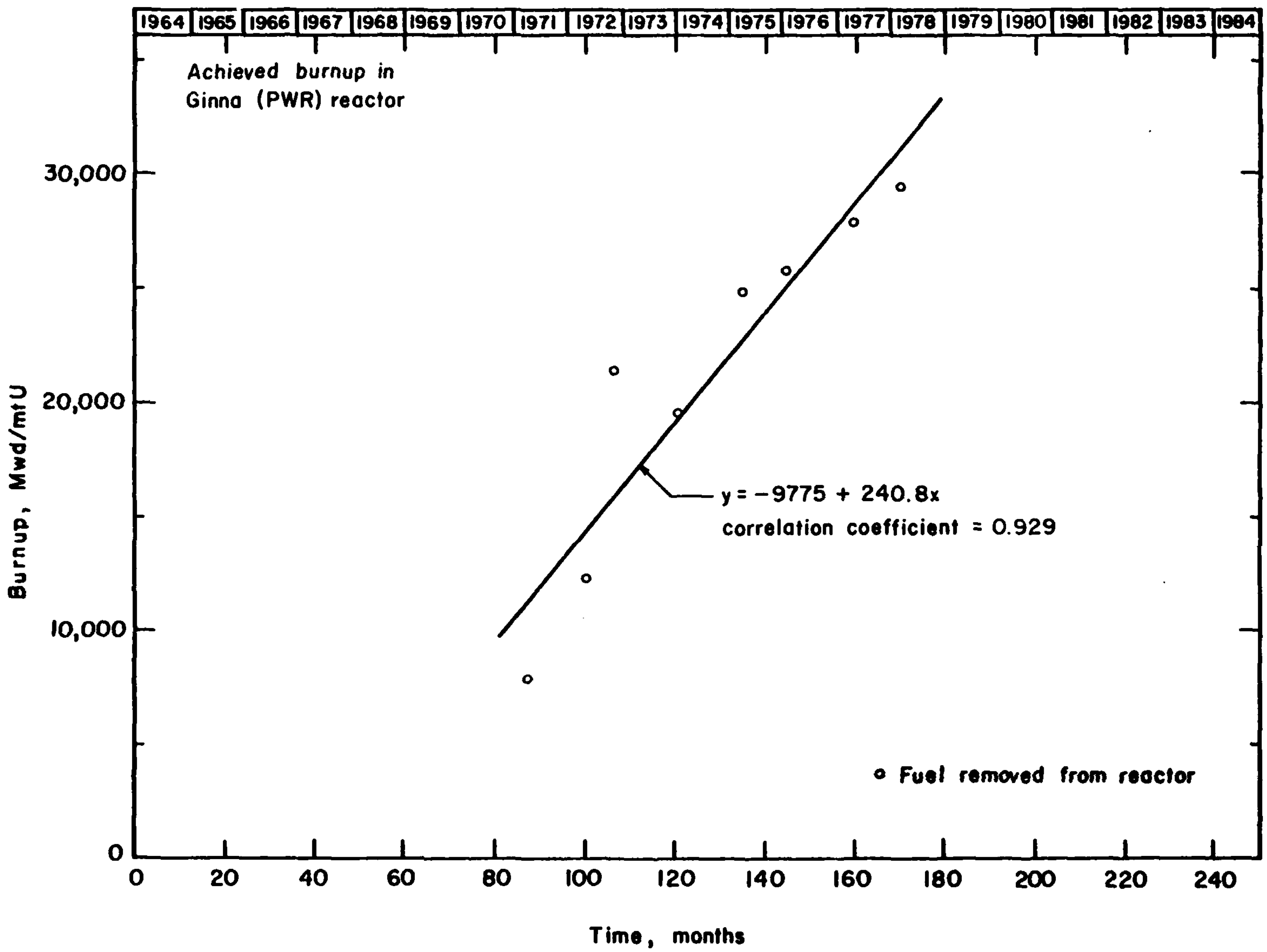

Fig. 7. History of discharge fuel burnup achieved in the Ginna reactor.

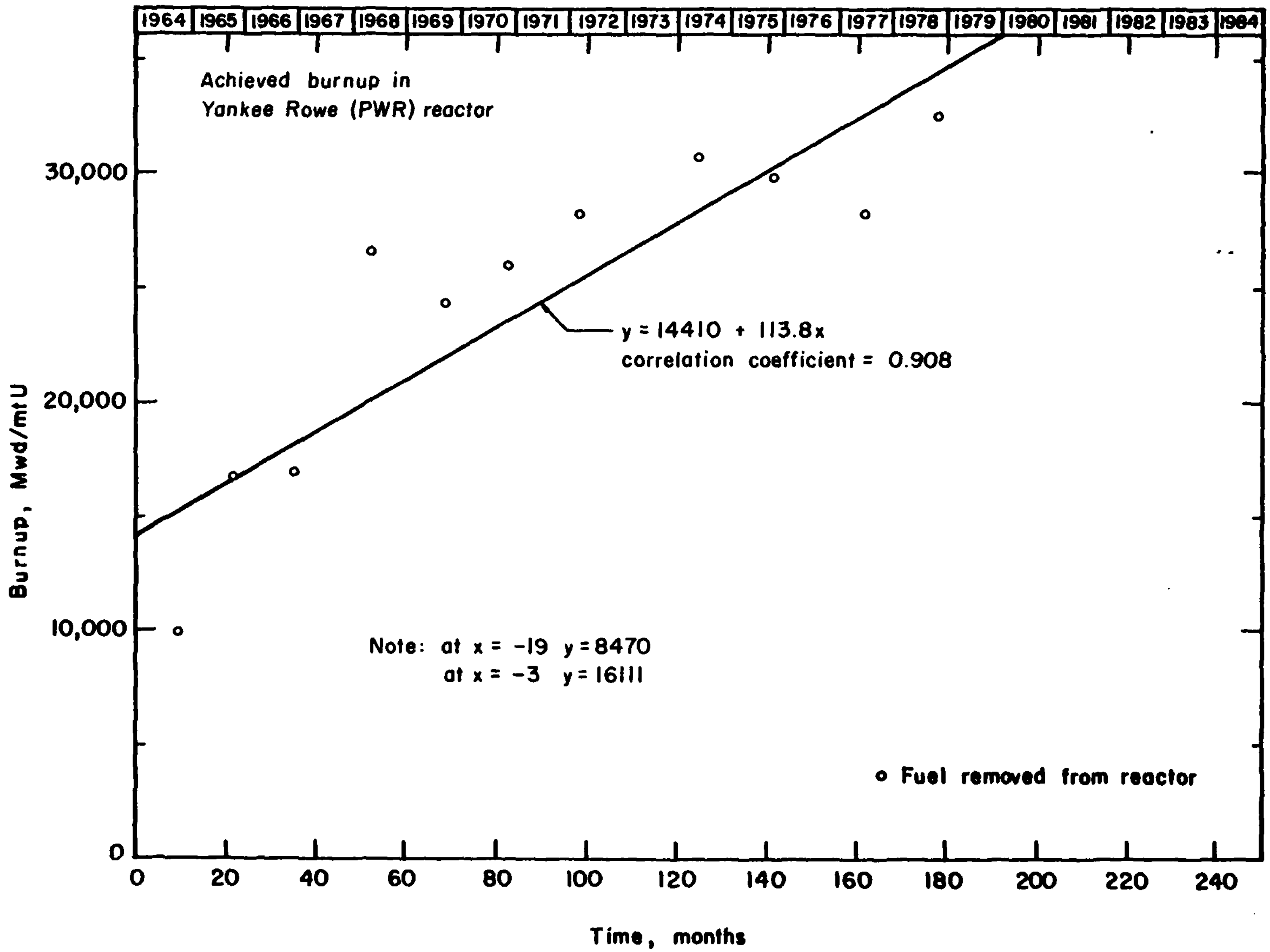

Fig. 8. History of discharge fuel burnup achieved in the Yankee Rowe reactor.

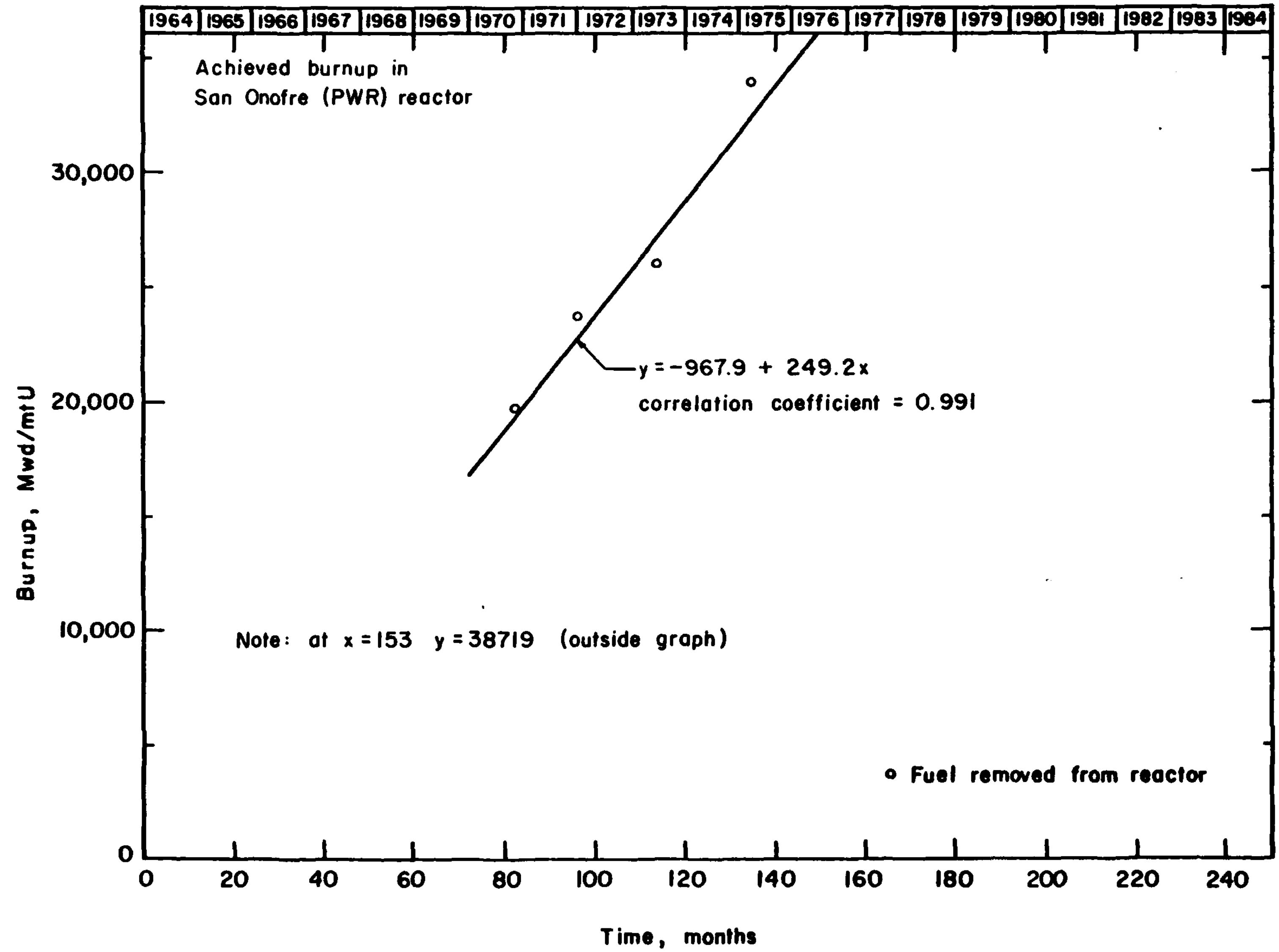

Fig. 9. History of discharge fuel burnup achieved in the San Onofre reactor.

Table I. COMPARISON OF ACHIEVED BURNUP IN UNITED STATES COMMERCIAL REACTORS

	History — No. of Years	Mean Fuel Burnup in 1978 Mwd/mtU	Projected Burnup in 2000 Mwd/mtU	Slope Change Per Month Mwd/mtU	Correlation Coefficient
Dresden 1 (BWR)	16	21033	38435	66	0.939
Big Rock Point (BWR)	12	27541	61293	128	0.939
General Electric BWRs		19333	40976	82	0.606
Haddam Neck (PWR)	8	31000	42730	44	0.453
Ginna (PWR)	7	33573	97150	241	0.929
Yankee Rowe (PWR)	18	34892	64932	114	0.908
San Onofre 1 (PWR)	8	43895	109634	249	0.991
Westinghouse PWRs		28840	51817	87	0.567

water reactors seem very likely by that time, especially in light of incentives to increase burnup that exist as a result of increasing ore costs and anticipated reduced availability.

The data indicate that fuel burnup is now in the steep portion of an S-shaped learning curve. Without any known technological barrier to reaching these exposure levels, significantly improved fuel burnups should be achievable at a rate at least commensurate with historical trends. Strong government programs could substantially accelerate the achievement of higher fuel burnup.

III. POTENTIAL IMPROVEMENT IN URANIUM UTILIZATION

The linear regression estimates of fuel burnup discussed in Part II indicate that burnup capability can be conservatively expected to achieve at least 45,000-50,000 Mwd/mtU for PWR fuel by the year 2000; and that BWR fuel will reach this level approximately 10 years later. These projections, from a historical perspective, are conservative. The state-of-the-art review below tends to confirm that they are reasonable objectives and could quite possibly be achieved sooner than the year 2000.

The burnup level of 45,000 Mwd/mtU is presently identified as a demonstration project objective in a DOE paper[(1)] presented at the November 1978 ANS conference in Washington, D.C. Duke Power and Arkansas Power will participate in this project, with the ultimate objective of demonstrating batch average burnup of 45,000 Mwd/mtU. It is significant that the objective of this program is to obtain a batch average burnup at this level, as opposed to the much more limited current experience of higher burnup in individual rods only. Successful completion of this project will provide a commercial scale demonstration of this performance objective.

A figure of 45,000 Mwd/mtU for average batch burnup appears to be reasonable and within current fuel rod design technology. Current PWR technology allows lead rod target burnup of 40,000 Mwd/mtU,[(2)] which is already within reach of the 45,000 Mwd/mtU figure. Fuel rods irradiated at Zorita have achieved the highest burnup to date from any commercial reactor. Peak rod average burnup in this reactor has reached 58,000 Mwd/mtU, with a peak pellet burnup of 65,000 Mwd/mtU. The purpose of the Zorita program was to demonstrate high power/burnup capability, and the fuel employed was commercial-design pressurized PWR fuel rods, which were also exposed to peak linear heat rates in excess of those normally used. Along with the data to be obtained in the Duke/Arkansas project, this experience should provide an adequate design basis for increasing PWR fuel burnup to 45,000 Mwd/mtU in the foreseeable future.

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(1) P. M. Lang, Future Trends in LWR Fuel to Improve Uranium Utilization, ANS Winter Meeting, Washington, D.C., November 12-16, 1978.

(2) D. H. Locke, et al., Water Fuel Performance, Nuclear Energy, No. 3, pp. 185-204, July 17, 1978.

Limitations to improved burnup performance in LWR fuel have reportedly[3] been reduced to acceptable levels, or eliminated, with the principal remaining concern being fuel-clad interactions (FCI). The basic theory of FCI damage is that gradual changes in fuel and clad dimensions caused by pellet creep, fission product swelling, fuel densification and relocation can cause uneven loading and stress concentration in the clad due to direct pellet-clad contact. Rapid changes in this contact interface should be avoided by limiting the rate of power change to permit fuel and clad to gradually accommodate each other. FCI failures have been observed to occur in fuel with appreciable exposure either during or following a local power increase. The presence of fission products causes cracking, introducing the generally accepted hypothesis that chemical embrittlement of the clad by released fission products is a contributing factor to FCI failure. It has generally been concluded that FCI failures are stress-corrosion related, caused by fission product species reacting predominately at locally stressed regions of the clad.

Design improvements already implemented by Westinghouse, General Electric, and the other vendors are claimed to eliminate other prior causes by rod failure and "minimize" FCI failure. Improvements introduced by General Electric that purportedly minimize FCI failures include short chamfered pellets, clad heat treatment modifications to reduce ductility variations, and improved pellet fabrication techniques. Westinghouse claims no significant problems with FCI failures, although they introduced the concept of rod pressurization in 1968 which, incidentally, reduces fuel-clad interaction.

With FCI damage mechanisms apparently defined and understood, it is expected that necessary design improvements can be introduced to control this problem. In addition to design modifications, both existing and proposed for LWR fuel, plants have also introduced operational restrictions in rate of power escalation to minimize the risk of FCI clad damage. The May 1977 ANS Topical Meeting on Fuel Performance[3] provided reasonable assurance that the FCI problem had been brought under control.

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(3) Water Reactor Fuel Performance, ANS Topical Meeting, St. Charles, Illinois, May 9-11, 1977.

In spite of technological advancements permitting burnups above 45,000 Mwd/mtU, significant licensing issues remain to be resolved. The updated ANS standard on fission gas release will show releases increasing a factor of 10 between 30,000 Mwd/mtU and 60,000 Mwd/mtU. As burnups increase from today's levels (Table I), attendant licensing concerns will include potentially higher source terms, and higher operating fuel temperatures from reduced pellet-clad gap conductivity. With commercial implementation (>50% of U.S. nuclear capacity) not expected for at least 10 years, sufficient time is available to resolve these issues and reach the 45,000 Mwd/mtU level.

An earlier report[4] showed that 45,000 Mwd/mtU was a near optimal burnup, from the uranium utilization standpoint, for typical PWR lattices using fuel enrichment as a variable to obtain adequate reactivity. Figure 10 indicates a potential reduction in U_3O_8 requirements over a 30-year plant life (operating at 1000 Mw(e) and 75% plant factor) from 6250 standard tons to 5750 standard tons, or approximately 8% savings in uranium requirements over the life of the plant.

The lower curve in Figure 10 represents the limit where increased fuel burnup is obtained by utilizing all the reactivity margins to maintain criticality (e.g., through continuous on-line refueling). Decreasing the refueling batch size also reduces the uranium resource requirements ($\sim$10% for semi-annual, 6-batch core refueling). However, this option is only practically available to one announced reactor project, the South Texas Westinghouse PWRs, which incorporate "rapid refueling" design features. Combining the effect of increased fuel burnup and decreased refueling batch size, is estimated to improve uranium resource utilization by about 18% in future LWRs. This potential improvement in uranium utilization can be realized only by incorporating the "rapid refueling" system in a new plant. Existing plants could not be backfitted At the present time licensing problems, higher capital cost, and potential downtime penalties from operating complications discourage its use.

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(4) Studies of Alternative Nuclear Technologies, Report SSA-106, Southern Science Applications, Inc., April 1978.

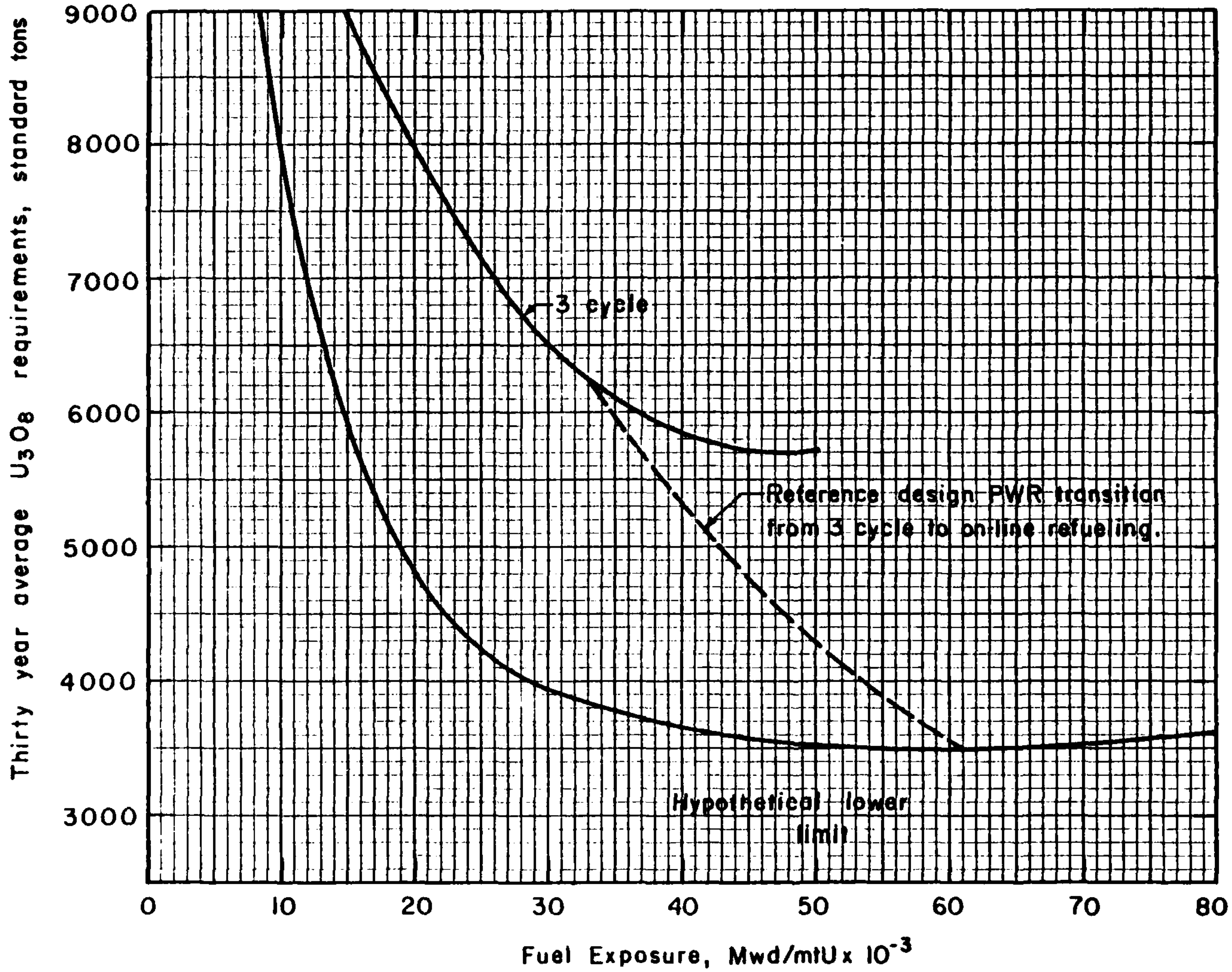

Fig. 10. U_3O_8 resource utilization as a function of discharge fuel burnup.

Due to licensing restrictions and other practical operating considerations such as load following performance, the ultimate range in uranium savings from increasing fuel burnup is cited as 10-20% in the DOE paper[1], which is in reasonable agreement with the value estimated above. This reference also indicates that increasing burnup would have the least impact on plant design and offers the earliest capability of implementation. With established trends demonstrating improved fuel burnup, and the referenced studies as a basis, uranium savings over present generation LWRs are expected to be at least 10%, and may well approach the 20% upper limit.

Additional uranium savings could be realized from other design improvements in Table II. Items 1 and 2 — decreased reload batch size and increased fuel burnup — discussed above offer the greatest potential for improved resource utilization on a timely basis and should probably be assigned the highest priority. In both cases, detailed evaluations (loading patterns, power distributions, reactivity coefficients, preliminary safety analyses, etc.) and experimental work (i.e., high burnup fuel assemblies) would be necessary. In addition, other possible schemes for fast reshuffling schemes (approaching as nearly as practical to on-line refueling) should be studied where modifications in reactor vessel and internals design may be considered (i.e., future reactors, but no retrofit to existing LWRs).

Second highest priority should probably be assigned to item 3 — full use of early batches of startup core. Although the potential improvement is small, the development cost should also be small and implementation could possibly be effected almost immediately, at least in reactors scheduled to start up in the near future. This category should also include recovery of energy in the partially burned fuel in the core at the end of reactor life. It is believed that some work along these lines has already been accomplished, but documented results have not been found in the literature.

Third highest priority should probably be assigned to items 4 and 9. The potential for improved resource utilization of item 4 (axial shuffling) warrants more detailed study to identify the magnitude of the potential improvement and the design/R&D/licensing problems that might be encountered in implementing axial shuffling in LWRs. Item 9 includes a number of possible

Table II. POTENTIAL URANIUM SAVINGS FROM DESIGN AND FUEL MANAGEMENT IMRPOVEMENTS

Improvement Type	Potential for Improved Uranium Utilization	Timeliness of Implementation	East of Backfit	Size of R&D Effort
1. Decreased reload batch size (rapid refueling)	M(H)	M	E	L(M)
2. Increased fuel burnup	M	N	C	M
3. Full use of early batches of startup core	L	N	B	L
4. Axial shuffling (including reconstitution/inversion of BWR fuel)	M	N/M	C/D	M/H
5. Spectral shift (mechanical, voids, coolant temp)	L/M	M	C/D	M/H
6. EOC stretchout/coastdown	L	N	A	L
7. Lattice changes	L/M	N/M	C	M
8. Enrichment zoning/blanket (axial or radial/depleted U)	L/M	N/M	B/C	M/H
9. Miscellaneous (better use of poisons, more uniform batch burnup, spiked fuel, use of fertile poisons, alternate fuel material, vented fuel, etc.)	L/M	N/M	C/D	M/H

Table II. POTENTIAL URANIUM SAVINGS FROM DESIGN AND FUEL MANAGEMENT IMPROVEMENTS (Continued)

EXPLANATION OF TERMS

Potential for Improved Uranium Utilization

By definition, improved uranium utilization means an increase in electric energy produced per unit uranium ore mined.

H = High (>10%)
M = Moderate (2-10%)
L = Low (<2%)

Timeliness of Implementation

Substantial (∿ 50%) penetration of applicable U.S. nuclear capacity by:

N = Near Term (through 1988)
M = Medium Term (1989-1999)
L = Long Term (2000 and later)

East of Backfit

A = Different operation of present reactors
B = Different arrangement of fuel of current design
C = Redesigned fuel
D = Plant modifications which can be backfitted
E = New Plants only

Size of R&D Effort

H = High (>$50 million)
M = Medium ($10-50 million)
L = Low (<$10 million)

schemes that have as yet not been evaluated in sufficient detail to assess their potential for improved resource utilization or the problems that may be associated with their implementation. Certainly, these possible schemes warrant study. Basically, the problem is to identify all areas of excess reactivity utilization and to seek methods of reducing the margins under operating conditions. For example, if the poisoning and the excess reactivity margin used to control xenon could be eliminated, resource utilization could be improved by about 16%.

Fourth highest priority should be assigned to item 5 — spectral shift. Without detailed analysis, it is difficult to visualize the potential improvement in resource utilization. Basically, this is a mechanism for reactivity control, in anticipation that somewhat enhanced fuel burnup could be achieved without an additional enrichment penalty. Plant modifications and the effects on plant thermal efficiency would also have to be considered. The spectral shift concept with D_2O shows only about 10% improvements in resource utilization, and the other methods of spectral shift contemplated in item 5 would probably be significantly less effective.

Item 6 — end of cycle stretchout/coastdown — with the potential being dependent upon such factors as the utility peak demand period or the number of failed fuel elements in the core (i.e., approach to Tech. Spec. limit). Consequently, any projected potential improvements in resource utilization would likely not be dependable.

Items 7 and 8 — lattice changes and enrichment zoning — should probably be assigned the lowest priority. Existing studies on lattice changes do not lend enough confidence of significant improvements. The potential improvement in fuel utilization through lattice changes (water-to-fuel volume ratio) is illustrated by Fig. 11. Some improvement can be achieved with a water-to-fuel ratio greater than that in current water reactors, but safety considerations tend to yield an optimum nearer existing design conditions. Only limited confirmatory analytical investigations would seem justified at this time. One possible exception is the use of highly lumped fuel of a different design, analagous to the seed-blanket element concept of the so-called light water breeder reactor.

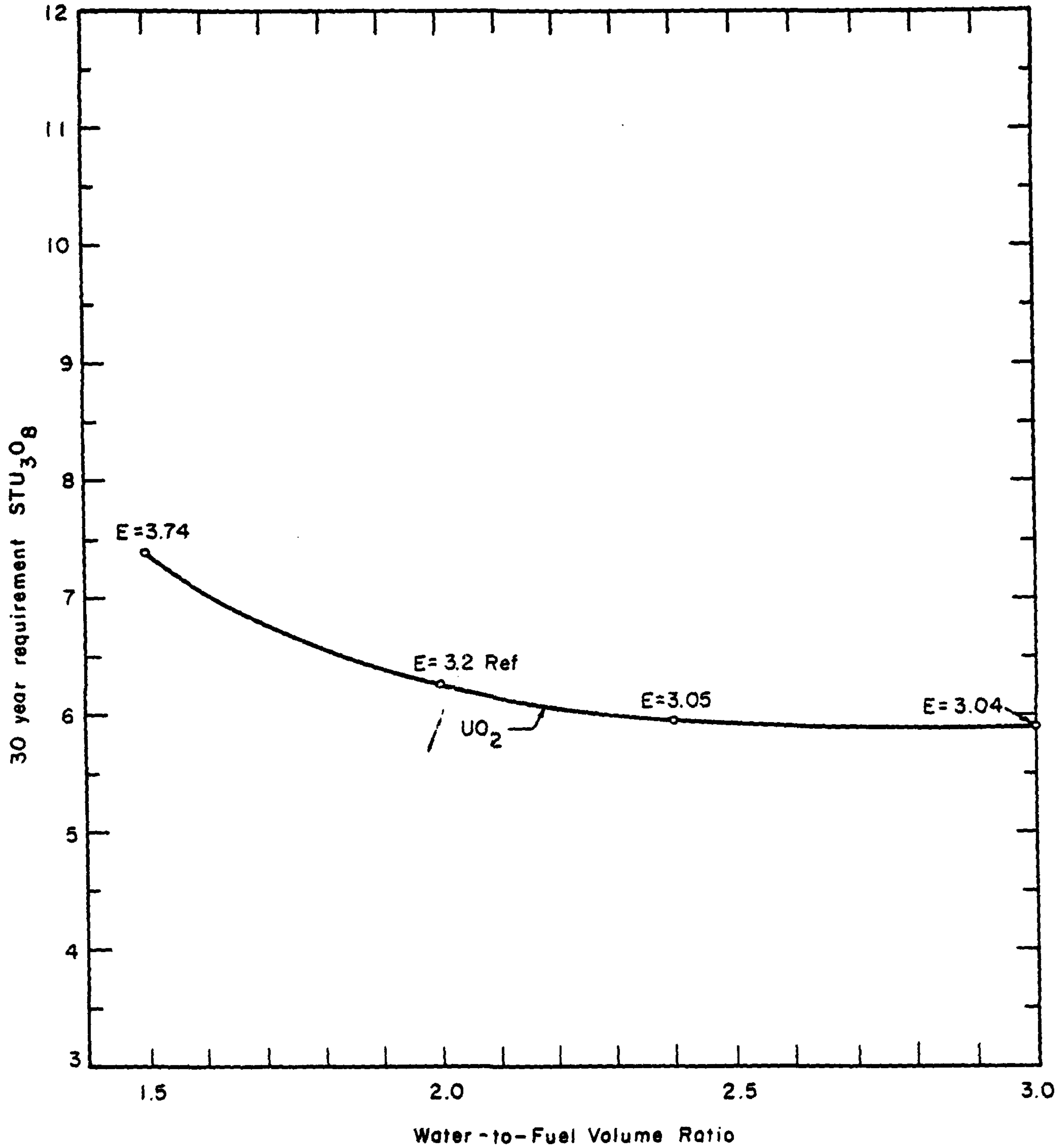

Fig. 11. Effect of changing water-to-UO_2 volume ratio on U_3O_8 resource utilization (Ref. PWR, 33000 MWD/MTU burnup)

The tabulated improvements that require changes in design or fuel management schemes (which generally are less in magnitude than burnup/ replacement batch size improvements) should be considered in light of the more significant costs and risks to be realized if these changes are implemented. It should also be emphasized that reduced uranium requirements are not strictly additive, e.g., the potential savings from two independent measures may not necessarily be symbiotic and could, in some cases, be contradictory. In any case, successful introduction of all these changes is very unlikely. Strictly on the basis of subjective judgement, a net gain of another 10-20% in uranium utilization may be attainable by design changes that may be combined with improved burnup to approach a total of 20-40%.

IV. ALTERNATIVE NUCLEAR TECHNOLOGIES

A. General

A recent study performed by Argonne(5) evaluated the uranium resource utilization benefits of U/Pu recycle. The assumptions used in this study included a 30-year plant life and 75% capacity factor. With uranium recycle, U_3O_8 requirements were about 20% less than for the once-through cycle; for plutonium recycle, U_3O_8 requirements were reduced an additional 20%. It was reported at the ANS Topical Meeting(3) that reprocessing would reduce uranium requirements by approximately 30%.

Beginning with instrumented rods and test reactors, the LWR industry has proceeded with extensive testing and destructive examination of UO_2 test rods, culminating in test batch irradiation at a commercial reactor, to demonstrate 45,000 Mwd/mtU burnup capability. Although the time required to complete similar work for a U/Pu recycle fuel could be accelerated, it is anticipated that between 5 and 10 years of testing, examination, and design code development would be required to achieve a licensable product to be introduced on a broad commercial scale. The remaining practical problems concerning manufacturing and quality control techniques could be pursued in parallel with the more time-consuming program required to demonstrate safety and reliability. Fabrication development would, however, require additional expenditure, and remote handling requirements would result in a higher cost of product to the utility. U/Pu recycle has, however, been demonstrated on a commercial scale in several European reactors.

Industry participation and interest in U/Pu recycle has already been accomplished, and the basic appeal of recycling material already on hand well result in U/Pu recycle becoming accepted practice on a broad scale. The outstanding obstacle to this objective, of course, remains

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(4) Y. I. Chang, et al., Alternative Fuel Cycle Options: Performance Characteristics and Impact on Nuclear Power Growth Potential, Argonne National Laboratory, Sept 1977.

U.S. policies concerning reprocessing. Given a favorable policy in this regard, the best available estimate for plant lifetime savings in U_3O_8 requirements from reprocessing is approximately 25% over current and projected ore requirements.

B. Alternate Fuel Cycles

Introduction of an alternate fuel cycle requires demonstration, both by prototype irradiation on a batch basis and by licensing submittals, substantiating that the design is reliable from the utility viewpoint and safe from the regulatory viewpoint. The principal interest, at the present time, lies in the denatured fuel cycle (uranium and thorium oxide) largely because of weapons proliferation concerns. However, despite the reduction in plutonium production, the U_3O_8 requirements are substantially increased, in the absence of reprocessing and recycle of U-233 (i.e., the stowaway fuel cycle). A number of calculations have been made in an effort to identify the effect of various parameters on uranium resource utilization. Figure 12 presents an illustration of resource utilization covering a broad range of alternate fuel cycles. Varying levels and values of enrichment and thorium denaturing have been combined with the use of fuel loadings at reduced density (by substitution with inert material) to determine the subsequent burnup and resource requirements for the reference reactivity requirements. Cases along the top of the profile are at nominal density, while cases below these are at reduced density, all for the same energy production in each fuel cycle. As shown, several reduced density cases yield resource improvements compared to the reference PWR case. Fuel exposure required for these cases is, however, significantly larger than expected to be attained within technological constraints. For all cases of practical interest, U_3O_8 resource requirements are greater than the reference UO_2 case (current design) without recycle.

C. Neutron Economy

The advantages of alternate nuclear technologies are based on efficient neutron utilization. Investigation of various fuel cycles and reactor types help identify the effect of neutron utilization on uranium resource utilization.

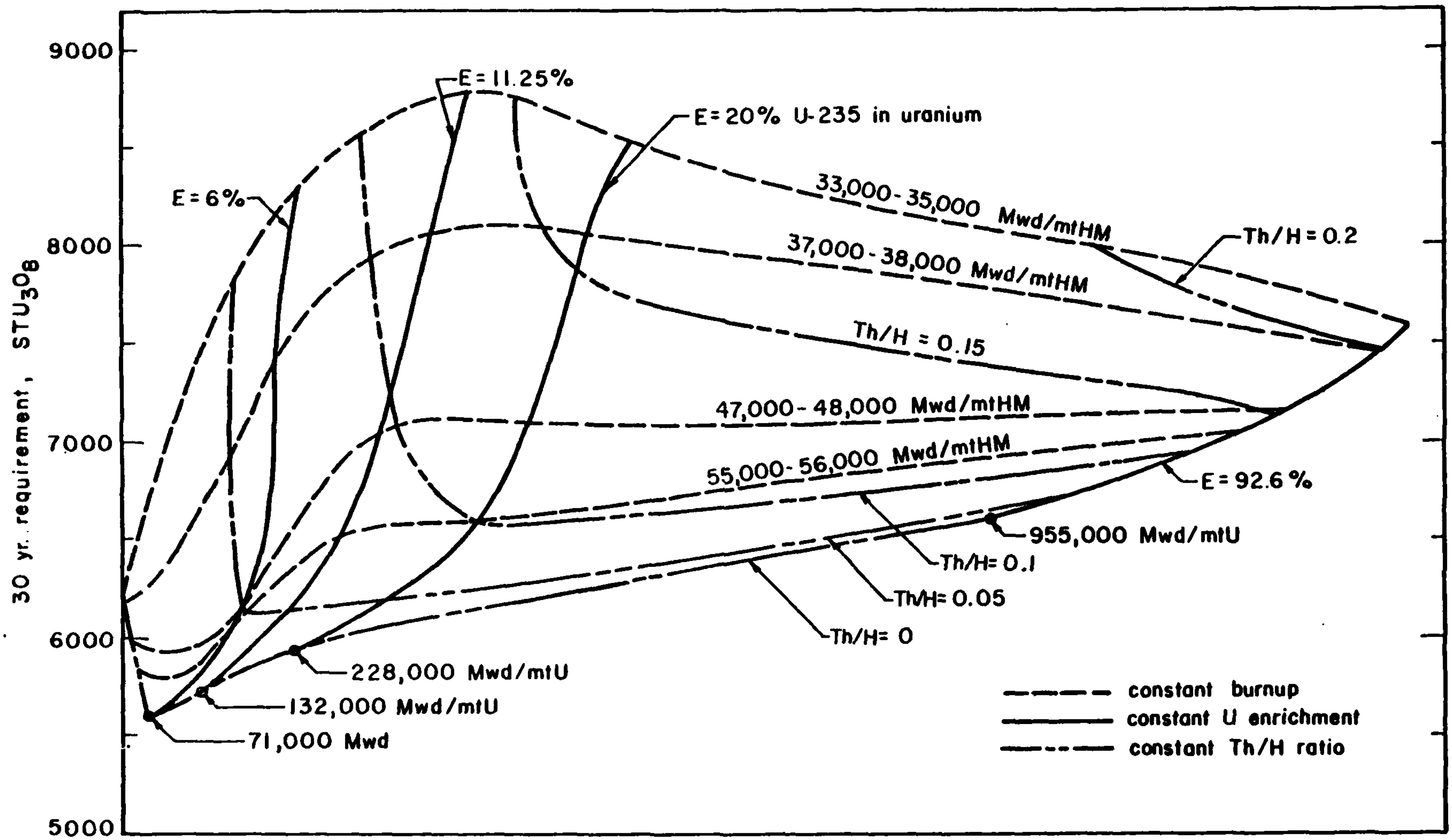

Fig. 12. Uranium resource utilization for various denatured fuel cycles.

Table III provides an accounting of the relative neutron consumption for various fuel cycles and for differing reactor designs. That breakdown provides an indication of neutron utilization in fissile and fertile materials and also the proportional loss in nonproductive ways. Such a breakdown may be constructive as an indicator of areas and potential degrees of improvement. In most of the cases shown in Table III, the calculations were made with a point burnup code, not explicitly including leakage and control effects, but allowing a reactivity margin at end-of-life for these factors. All cases are normalized to 1000 Mwe, at a 75% capacity factor.

For the reference PWR case, Fig. 13 shows the variation throughout burnup of the neutron fraction absorbed (or lost) in the various materials. Three irradiation cycles were used, with the soluble boron concentration decreasing linearly in each cycle from 1000 ppm initially to 0 at the end of the cycle. Leakage, used in the calculations to maintain criticality actually includes leakage loss as well as absorption in all other control mechanisms used to provide operating margins.

Table III. NEUTRON ECONOMY IN VARIOUS FUEL AND REACTOR CONCEPTS, THROWAWAY FUEL CYCLES

Concept	Average Percent Neutrons Absorbed By: U-235	U-238/Th	Fissile Pu/U-233	Clad & Mod	Fission Products	Soluble Boron	Leakage & Control	INTEGRATED CONVERSION RATIO	Kilograms Fissioned/Fuel Cycle: U-235	U-238	Th	Pu	U-233	Total
1. Reference PWR	27.5	26.8	20.5	5.0	11.2	3.5	5.6	.57	504	63		300		867
2. Reference PWR	32.6	28.9	21.0	5.8	11.7	*	*	.57	504	57		300		861
3. Reference PWR, 4% E, 44,000 Mwd/mtU	32.9	27.5	21.3	5.1	13.1	*	*	.55	499	56		301		856
4. PWR, W/F 1.5, 4% E, 35,900 Mwd/mtU	33.4	30.9	20.1	3.7	11.7	*	*	.59	520	68		293		881
5. PWR, 3.2% E, 0 Xe, 38,300 Mwd/mtU	31.1	29.2	22.9	5.9	10.9	*	*	.58	477	57		329		863
6. Hypothetical Limit, 3.2% E, 60,000 Mwd/mtU, on line refueling	21.5	28.9	26.8	6.0	17.0	*	*	.69	352	64		436		852
7. Denatured Fuel, 11.25% E, 60% Th, 34,700 Mwd/mtHM	36.5	14.2/ 18.5 32.7	9.9/ 7.5 17.4	4.5	9.0	*	*	.62	584	21	8	139	138	890
8. Denatured Fuel, 20% E, 78% Th, 35,250 Mwd/mtHM	36.7	9.6/ 23.2 32.8	7.3/ 9.7 17.0	4.7	8.8	*	*	.62	586	10	10	101	180	887
9. Denatured Fuel, 92.6% E, 91% Th, 91,800 Mwd/mtHM	19.8	1.0/ 24.3 25.3	1.1/ 15.6 16.7	4.4	13.9	*	*	.47	548		11	14	268	841
10. CANDU, Reference Nat U, 8500 Mwd/mtU	24.2	36.0	24.8	4.2	8.7	NA	2.1	.79	494	13		439		946
11. CANDU, Reference Nat U, 8500 Mwd/mtU	25.1	36.8	24.9	4.2	8.8	NA	*	.79	496	12		438		946
12. CANDU, 1.2% E, 25,700 Mwd/mtU	19.5	31.4	30.2	4.0	14.8	NA	*	.75	330	11		522		863
13. CANDU, 1.5% E, 35,000 Mwd/mtU	19.0	29.9	30.4	3.9	16.8	NA	*	.72	308	11		540		859
14. HTGR, Reference 92.6% E, 95.6% Th, 96,400 Mwd/mtHM	19.5	0.4/ 37.6 38.0	0.5/ 27.4 27.9	1.9	12.8	NA	*	.84	249		2	6	445	702
15. HTGR, 35% E, 80% Th, 98,040 Mwd/mtHM	25.4	10.3/ 25.4 35.7	10.8/ 14.5 25.3	1.0	12.6	NA	*	.76	343	1	1	134	240	719
16. HTGR, 20% E, 20% Th, 98,000 Mwd/mtHM	36.4	26.2/ 7.1 33.3	16.1/ 2.6 18.7	0.5	11.2	NA	*	.65	481	5		214	43	743

* Point burnup calculation, soluble boron and leakage not explicitly included.

** Fission products includes other actinide elements produced during the burnup process.

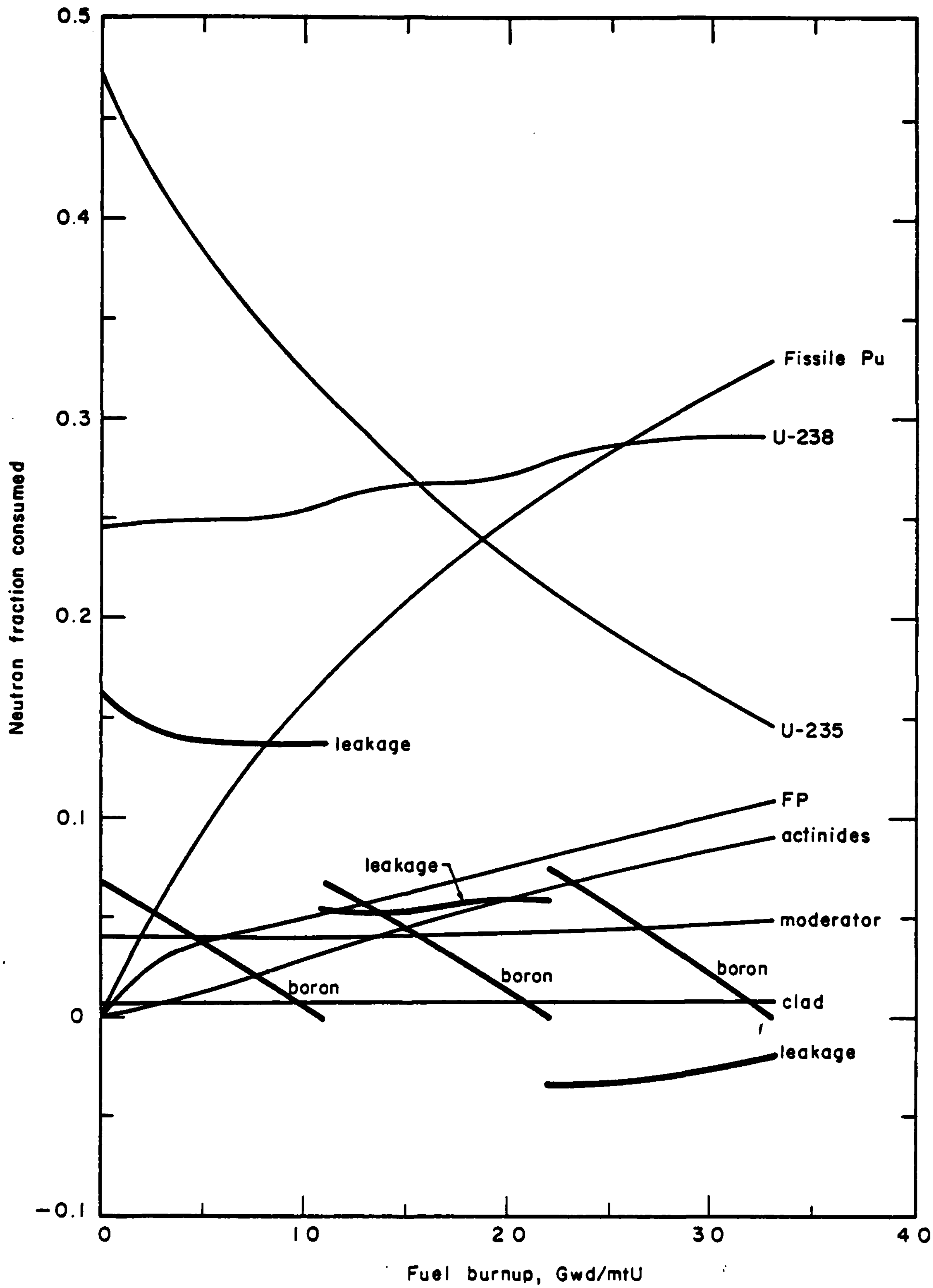

Fig. 13. Fractions of neutrons absorbed in various materials during fuel burnup in reference PWR.

APPENDIX A

FORM:

NUCLEAR ASSURANCE CORPORATION
FUEL-TRAC REPORT 07 NOV 78

SORTED BY REACTOR/DISCHARGE DATE
SORT IDENTIFIERS:R/D

IDENTIFIER		DESCRIPTION	RANGE
N	1010	/*NAC BATCH NUMBER AND LOADING	ALL
D	1080	/*SHUTDOWN DATE	/FEB60=DEC78/
B	1145	/ DISCHARGE BURNUP (MWD/MTU)	/1=99999/
R	1014	/REACTOR NAME - UNIT	ALL
C	1011	COUNTRY	U.S.A.

OUTPUT COLUMN ORDER:R D N B

*DATA IS SELECTED ON THE BASIS OF THE FOLLOWING
QUESTION (REFERENCING RANGES IDENTIFIED ABOVE) :
QUESTION C.AND.D.AND.B

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:ARK NUCL 1			
ARK NUCL 1	JAN 77	R01	16237
ARK NUCL 1	FEB 78	R02B	26000*
ARK NUCL 1	FEB 78	R02A	26000

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:D ARNOLD 1			
D ARNOLD 1	MAY 75	R01	8000
D ARNOLD 1	FEB 76	R02A	16105
D ARNOLD 1	FEB 76	R02B	13585
D ARNOLD 1	MAR 77	R03A	16954
D ARNOLD 1	MAR 77	R03C	11410
D ARNOLD 1	MAR 77	R03B	20790
D ARNOLD 1	MAR 77	R03D	17651
D ARNOLD 1	MAR 78	R04	23579

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:BEAVER VY1			
BEAVER VY1	MAR 76	F03	34410
BEAVER VY1	MAR 76	F02	34410
BEAVER VY1	MAR 76	F01	34410
BEAVER VY1	NOV 78	R01	14600

L-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
REACTOR:BIG ROCK			
BIG ROCK	JUL 62	F01	26200
BIG ROCK	APR 66	R01	5351
BIG ROCK	SEP 66	R02	9703
BIG ROCK	MAY 67	R03A	10263
BIG ROCK	MAY 67	R03B	6028
BIG ROCK	MAY 67	R03C	13816
BIG ROCK	FEB 68	R04A	7625
BIG ROCK	FEB 68	R04B	12146
BIG ROCK	FEB 68	R04C	18007
BIG ROCK	JUN 68	R05C	10305
BIG ROCK	JUN 68	R05B	3575
BIG ROCK	JUN 68	R05A	14300
BIG ROCK	JUN 68	R05D	19489
BIG ROCK	APR 69	R06A	10864
BIG ROCK	APR 69	R06C	15782
BIG ROCK	APR 69	R06B	18060
BIG ROCK	APR 69	R06D	5937
BIG ROCK	FEB 70	R07A	4244
BIG ROCK	FEB 70	R07C	13324
BIG ROCK	FEB 70	R07B	16221
BIG ROCK	FEB 70	R07D	4895
BIG ROCK	FEB 70	R07E	9231
BIG ROCK	FEB 71	R08A	9623
BIG ROCK	FEB 71	R08E	9817
BIG ROCK	FEB 71	R08D	23436
BIG ROCK	FEB 71	R08C	9200
BIG ROCK	FEB 71	R08B	19457
BIG ROCK	MAR 72	R09B	16637
BIG ROCK	MAR 72	R09A	23254
BIG ROCK	MAR 72	R09C	20453
BIG ROCK	MAR 73	R10D	23716
BIG ROCK	MAR 73	R10C	17156
BIG ROCK	MAR 73	R10B	21054
BIG ROCK	MAR 73	R10A	8257
BIG ROCK	MAR 74	R11A	21387
BIG ROCK	MAR 74	R11C	26200
BIG ROCK	MAR 74	R11B	27575
BIG ROCK	MAR 74	R11C	26200
BIG ROCK	MAR 74	R11C	26200
BIG ROCK	JUN 74	R12F	27811
BIG ROCK	JUN 74	R12E	21968
BIG ROCK	JUN 74	R12D	21968
BIG ROCK	JUN 74	R12C	26509
BIG ROCK	JUN 74	R12B	17572

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
BIG ROCK	JUN 74	R12A	24787
BIG ROCK	JAN 76	R13D	23257
BIG ROCK	JAN 76	R13B	19101
BIG ROCK	JAN 76	R13C	24968
BIG ROCK	JAN 76	R13A	24968
BIG ROCK	JUL 77	R14A	25993
BIG ROCK	JUL 77	R14C	22911
BIG ROCK	JUL 77	R14B	17560
BIG ROCK	OCT 78	R15C	28369
BIG ROCK	OCT 78	R15B	28369
BIG ROCK	OCT 78	R15A	16796
BIG ROCK	OCT 78	R15D	29356

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:BROWNS FY1			
BROWNS FY1	SEP 77	R01	10250
BROWNS FY1	OCT 78	R02	26688

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:BROWNS FY2			
BROWNS FY2	MAR 78	R01B	9713
BROWNS FY2	MAR 78	R01A	9713

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:BROWNS FY3			
BROWNS FY3	SEP 78	R01C	15030
BROWNS FY3	SEP 78	R01B	10600
BROWNS FY3	SEP 78	R01A	10500

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:BRUNSWICK1			
BRUNSWICK1	OCT 76	F01	28733

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:BRUNSWICK2			
BRUNSWICK2	MAR 77	R01	15483
BRUNSWICK2	SEP 77	R02B	7000
BRUNSWICK2	SEP 77	R02A	7000

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:CALV CLFS1			
CALV CLFS1	JAN 77	R01C	18000
CALV CLFS1	JAN 77	R01B	20000
CALV CLFS1	JAN 77	R01A	18000
CALV CLFS1	MAR 78	R02	27084

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:CALV CLFS2			
CALV CLFS2	OCT 78	R01B	18405
CALV CLFS2	OCT 78	R01A	9500

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:CON.YANKEE			
CON.YANKEE	JUN 67	F01	26400
CON.YANKEE	JUN 67	F03	26400
CON.YANKEE	JUN 67	F02	26400
CON.YANKEE	APR 70	R01B	25375
CON.YANKEE	APR 70	R01A	19454
CON.YANKEE	APR 71	R02C	27237
CON.YANKEE	APR 71	R02B	26345*
CON.YANKEE	APR 71	R02A	26345
CON.YANKEE	JUN 72	R03A	30853
CON.YANKEE	JUN 72	R03B	31573
CON.YANKEE	JUL 73	R04A	27511
CON.YANKEE	JUL 73	R04C	25271
CON.YANKEE	JUL 73	R04B	28470
CON.YANKEE	JUL 73	R04F	32679
CON.YANKEE	JUL 73	R04E	27600
CON.YANKEE	JUL 73	R04D	25685
CON.YANKEE	MAY 75	R05A	33416
CON.YANKEE	MAY 75	R05D	33118
CON.YANKEE	MAY 75	R05C	29102
CON.YANKEE	MAY 75	R05B	33058
CON.YANKEE	MAY 76	R06A	30512
CON.YANKEE	MAY 76	R06E	25500*
CON.YANKEE	MAY 76	R06D	36199
CON.YANKEE	MAY 76	R06C	25500*
CON.YANKEE	MAY 76	R06B	32378
CON.YANKEE	MAY 76	R06F	25500*
CON.YANKEE	OCT 77	R07A	33528
CON.YANKEE	OCT 77	R07B	33528
CON.YANKEE	DEC 78	R08A	32657
CON.YANKEE	DEC 78	R08D	20000
CON.YANKEE	DEC 78	R08C	25503*
CON.YANKEE	DEC 78	R08B	25503

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:DC COOK 1			
DC COOK 1	DEC 76	R01	18940
DC COOK 1	APR 78	R02	29050

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:COOPER			
COOPER	SEP 76	R01B	13196
COOPER	SEP 76	R01A	9950
COOPER	OCT 77	R02B	10896
COOPER	OCT 77	R02A	19561
COOPER	APR 78	R03	19747

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:CRYSTAL R3			
CRYSTAL R3	MAR 78	R01	14937

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:DRESDEN 1			
DRESDEN 1	NOV 62	R01A	6383
DRESDEN 1	NOV 62	R01C	6485
DRESDEN 1	NOV 62	R01B	6680
DRESDEN 1	APR 64	R02C	5999
DRESDEN 1	APR 64	R02B	10272
DRESDEN 1	APR 64	R02A	9590
DRESDEN 1	MAR 65	R03A	10323
DRESDEN 1	MAR 65	R03C	7827
DRESDEN 1	MAR 65	R03B	14631
DRESDEN 1	JAN 67	R04D	8590
DRESDEN 1	JAN 67	R04C	12200
DRESDEN 1	JAN 67	R04B	12307
DRESDEN 1	JAN 67	R04A	12200
DRESDEN 1	FEB 68	R05A	8956
DRESDEN 1	FEB 68	R05C	11820
DRESDEN 1	FEB 68	R05B	15053
DRESDEN 1	SEP 69	R06A	18195
DRESDEN 1	SEP 69	R06D	23122
DRESDEN 1	SEP 69	R06C	6323
DRESDEN 1	SEP 69	R06B	10733
DRESDEN 1	SEP 69	R06E	18195
DRESDEN 1	SEP 69	R06H	15798
DRESDEN 1	SEP 69	R06G	17408
DRESDEN 1	SEP 69	R06F	22815
DRESDEN 1	SEP 71	R07A	16107
DRESDEN 1	SEP 71	R07C	17367
DRESDEN 1	SEP 71	R07B	16310
DRESDEN 1	OCT 73	R08A	17206
DRESDEN 1	OCT 73	R08B	18553
DRESDEN 1	SEP 74	R09A	16500
DRESDEN 1	SEP 74	R09B	17822
DRESDEN 1	SEP 74	R09C	18640
DRESDEN 1	SEP 75	R10A	16500
DRESDEN 1	SEP 75	R10B	18452
DRESDEN 1	JUN 77	R11A	23500
DRESDEN 1	JUN 77	R11B	18988
DRESDEN 1	NOV 78	R12C	18635
DRESDEN 1	NOV 78	R12B	16500
DRESDEN 1	NOV 78	R12A	19255

FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
**REACTOR:DRESDEN 2			
DRESDEN 2	JUN 70	R01	364
DRESDEN 2	FEB 71	R02A	1418
DRESDEN 2	FEB 71	R02B	1791
DRESDEN 2	FEB 72	R03	4479
DRESDEN 2	NOV 74	R04	12021
DRESDEN 2	MAR 76	R05A	7228*
DRESDEN 2	MAR 76	R05C	21300
DRESDEN 2	MAR 76	R05B	13540
DRESDEN 2	SEP 77	R06	21500

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

***REACTOR:DRESDEN 3

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
DRESDEN 3	MAR 73	R01	7070
DRESDEN 3	MAR 74	R02	10970
DRESDEN 3	APR 75	R03	11500
DRESDEN 3	SEP 76	R04	18000
DRESDEN 3	MAR 78	R05	21000

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:JA FITZPAT			
JA FITZPAT	JUN 77	R01	8258
JA FITZPAT	SEP 78	R02	17170

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:F CALHOUN1			
F CALHOUN1	FEB 75	R01B	13937*
F CALHOUN1	FEB 75	R01A	8515
F CALHOUN1	OCT 76	R02A	22200
F CALHOUN1	OCT 76	R02B	17000
F CALHOUN1	SEP 77	R03A	28790
F CALHOUN1	SEP 77	R03D	26839
F CALHOUN1	SEP 77	R03C	29345
F CALHOUN1	SEP 77	R03B	27041
F CALHOUN1	OCT 78	R04A	24290
F CALHOUN1	OCT 78	R04D	8775
F CALHOUN1	OCT 78	R04C	34940
F CALHOUN1	OCT 78	R04B	28039

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:R.E.GINNA			
R.E.GINNA	MAR 71	R01	7715
R.E.GINNA	APR 72	R02C	11036
R.E.GINNA	APR 72	R02B	17825
R.E.GINNA	APR 72	R02A	18321
R.E.GINNA	OCT 72	R03A	21479
R.E.GINNA	OCT 72	R03B	21086
R.E.GINNA	JAN 74	R04A	25135
R.E.GINNA	JAN 74	R04B	13878*
R.E.GINNA	MAR 75	R05A	26619*
R.E.GINNA	MAR 75	R05H	24187
R.E.GINNA	MAR 75	R05G	25615*
R.E.GINNA	MAR 75	R05F	25615*
R.E.GINNA	MAR 75	R05E	24554
R.E.GINNA	MAR 75	R05D	18993
R.E.GINNA	MAR 75	R05C	26619*
R.E.GINNA	MAR 75	R05B	26619*
R.E.GINNA	JAN 76	R06A	18736
R.E.GINNA	JAN 76	R06E	27822
R.E.GINNA	JAN 76	R06D	29939*
R.E.GINNA	JAN 76	R06C	27549
R.E.GINNA	JAN 76	R06B	24959
R.E.GINNA	APR 77	R07D	24398
R.E.GINNA	APR 77	R07C	29077
R.E.GINNA	APR 77	R07B	25787
R.E.GINNA	APR 77	R07A	33210
R.E.GINNA	APR 77	R07F	29915
R.E.GINNA	APR 77	R07E	25251
R.E.GINNA	MAR 78	R08B	32463
R.E.GINNA	MAR 78	R08A	31171
R.E.GINNA	MAR 78	R08E	27620
R.E.GINNA	MAR 78	R08D	25475
R.E.GINNA	MAR 78	R08C	30736

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:HATCH 1			
HATCH 1	MAR 77	R01	9500
HATCH 1	MAR 78	R02	18000

*FUEL-TPAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:INDIAN PT1			
INDIAN PT1	SEP 67	R01	12665
INDIAN PT1	FEB 69	R02	19039
INDIAN PT1	MAR 70	R03	23457
INDIAN PT1	DEC 72	R04	25247
INDIAN PT1	NOV 74	R05	25000

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:INDIAN PT2			
INDIAN PT2	APR 73	F01	30000
INDIAN PT2	APR 73	F03	30000
INDIAN PT2	APR 73	F02	30000
INDIAN PT2	APR 76	R01B	17911
INDIAN PT2	APR 76	R01A	17500
INDIAN PT2	FEB 78	R02B	27333
INDIAN PT2	FEB 78	R02A	35532

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:INDIAN PT3			
INDIAN PT3	JUN 78	R01B	18198*
INDIAN PT3	JUN 78	R01A	18198

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:KEWAUNEE 1			
KEWAUNEE 1	FEB 76	R01	16500
KEWAUNEE 1	JAN 77	R02A	29500
KEWAUNEE 1	JAN 77	R02B	25644
KEWAUNEE 1	APR 78	R03A	36425
KEWAUNEE 1	APR 78	R03B	34268

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:ME YANKEE			
ME YANKEE	SEP 72	F01	30000
ME YANKEE	SEP 72	F03	30000
ME YANKEE	SEP 72	F02	30000
ME YANKEE	JUN 74	R01B	11400
ME YANKEE	JUN 74	R01A	11854
ME YANKEE	JUN 74	R01C	11500
ME YANKEE	MAY 75	R02A	1053
ME YANKEE	MAY 75	R02C	6100
ME YANKEE	MAY 75	R02B	6291
ME YANKEE	MAY 75	R02D	6200
ME YANKEE	APR 77	R03A	17100
ME YANKEE	APR 77	R03B	17100
ME YANKEE	JUL 78	R04	26000

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:MILLSTONE1			
MILLSTONE1	SEP 72	R01E	7678
MILLSTONE1	SEP 72	R01D	9564*
MILLSTONE1	SEP 72	R01C	9564
MILLSTONE1	SEP 72	R01B	7678*
MILLSTONE1	SEP 72	R01A	7678*
MILLSTONE1	AUG 74	R02	18575
MILLSTONE1	SEP 75	R03	16189
MILLSTONE1	OCT 76	R04B	9200*
MILLSTONE1	OCT 76	R04A	19974
MILLSTONE1	MAR 78	R05B	19881
MILLSTONE1	MAR 78	R05A	19881
MILLSTONE1	MAR 78	R05H	24826
MILLSTONE1	MAR 78	R05G	22909
MILLSTONE1	MAR 78	R05F	22909
MILLSTONE1	MAR 78	R05E	15138*
MILLSTONE1	MAR 78	R05D	26945
MILLSTONE1	MAR 78	R05C	15138

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:MILLSTONE2			
MILLSTONE2	JUL 75	F02	43700
MILLSTONE2	JUL 75	F01	43700
MILLSTONE2	JUL 75	F03	43700
MILLSTONE2	NOV 77	R01A	15943
MILLSTONE2	NOV 77	R01B	16000X

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:MONTICELLO			
MONTICELLO	MAR 73	R01A	7400
MONTICELLO	MAR 73	R01B	7100*
MONTICELLO	MAR 74	R02	14240
MONTICELLO	JAN 75	R03	16852
MONTICELLO	SEP 75	R04A	16500
MONTICELLO	SEP 75	R04D	17108
MONTICELLO	SEP 75	R04C	17108
MONTICELLO	SEP 75	R04B	17108
MONTICELLO	SEP 77	R05A	21602
MONTICELLO	SEP 77	R05D	11001
MONTICELLO	SEP 77	R05C	13411
MONTICELLO	SEP 77	R05B	12790
MONTICELLO	OCT 78	R06A	20056
MONTICELLO	OCT 78	R06B	18200

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:9 MILE PT1			
9 MILE PT1	SEP 71	R01B	5200*
9 MILE PT1	SEP 71	R01A	5700
9 MILE PT1	APR 72	R02A	11000*
9 MILE PT1	APR 72	R02B	8010
9 MILE PT1	APR 73	R03A	13000*
9 MILE PT1	APR 73	R03B	12580
9 MILE PT1	MAR 74	R04	16800
9 MILE PT1	SEP 75	R05D	17130
9 MILE PT1	SEP 75	R05C	12331
9 MILE PT1	SEP 75	R05B	14000
9 MILE PT1	SEP 75	R05A	6000
9 MILE PT1	SEP 75	R05E	21000
9 MILE PT1	MAR 77	R06A	21756
9 MILE PT1	MAR 77	R06C	19415
9 MILE PT1	MAR 77	R06B	14000
9 MILE PT1	MAR 77	R06D	20131

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:N. ANNA 1			
N. ANNA 1	JAN 78	F01	32700
N. ANNA 1	JAN 78	F03	32700
N. ANNA 1	JAN 78	F02	32700

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:OCONEE 1			
OCONEE 1	OCT 74	R01A	11585
OCONEE 1	OCT 74	R01E	11560
OCONEE 1	OCT 74	R01D	11560
OCONEE 1	OCT 74	R01C	11585*
OCONEE 1	OCT 74	R01B	11585*
OCONEE 1	OCT 74	R01F	11560*
OCONEE 1	FEB 76	R02A	18488
OCONEE 1	FEB 76	R02B	19094
OCONEE 1	AUG 77	R03A	24232
OCONEE 1	AUG 77	R03B	23897
OCONEE 1	OCT 78	R04A	26198
OCONEE 1	OCT 78	R04C	10308
OCONEE 1	OCT 78	R04B	29451

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:OCONEE 2			
OCONEE 2	APR 76	R01C	13820*
OCONEE 2	APR 76	R01B	11463*
OCONEE 2	APR 76	R01A	14641
OCONEE 2	MAY 77	R02B	20394
OCONEE 2	MAY 77	R02A	24634
OCONEE 2	NOV 78	R03D	22000
OCONEE 2	NOV 78	R03C	19000
OCONEE 2	NOV 78	R03B	33974
OCONEE 2	NOV 78	R03A	29723

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:OCONEE 3			
OCONEE 3	SEP 76	R01D	16134*
OCONEE 3	SEP 76	R01C	13764*
OCONEE 3	SEP 76	R01B	14733*
OCONEE 3	SEP 76	R01A	16577*
OCONEE 3	SEP 76	R01E	16134
OCONEE 3	OCT 77	R02A	25160
OCONFE 3	OCT 77	R02B	24823
OCONEE 3	JUN 78	R03A	26200
OCONEE 3	JUN 78	R03B	17900

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:OYSTER CR1			
OYSTER CR1	SEP 71	R01	8861
OYSTER CR1	APR 72	R02	11866
OYSTER CR1	APR 73	R03	16384
OYSTER CR1	APR 74	R04	19793
OYSTER CR1	MAR 75	R05A	18280
OYSTER CR1	MAR 75	R05B	23316
OYSTER CR1	DEC 75	R06	21143
OYSTER CR1	APR 77	R07B	21402
OYSTER CR1	APR 77	R07A	23725
OYSTER CR1	APR 77	R07C	25207
OYSTER CR1	SEP 78	R08A	23218
OYSTER CR1	SEP 78	R08C	22207
OYSTER CR1	SEP 78	R08B	23218
OYSTER CR1	SEP 78	R08D	23710

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:PALISADES			
PALISADES	MAR 74	R01	24783
PALISADES	DEC 75	R02B	13175
PALISADES	DEC 75	R02A	27296
PALISADES	DEC 75	R02D	32479
PALISADES	DEC 75	R02C	18042
PALISADES	JAN 78	R03	13002

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP

***REACTOR:PEACH BOT2

PEACH BOT2	MAR 76	R01A	11065
PEACH BOT2	MAR 76	R01B	8046
PEACH BOT2	APR 77	R02	15550
PEACH BOT2	AUG 78	R03	26413

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:PEACH BOT3			
PEACH BOT3	DEC 76	R01B	19482
PEACH BOT3	DEC 76	R01A	15243
PEACH BOT3	APR 78	R02	19842

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:PILGRIM-1			
PILGRIM-1	DEC 73	R01	5998
PILGRIM-1	JAN 76	R02	11307
PILGRIM-1	AUG 77	R03	13500

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:PT.BEACH 1			
PT.BEACH 1	SEP 72	R01B	13177
PT.BEACH 1	SEP 72	R01A	19346
PT.BEACH 1	APR 74	R02B	25345
PT.BEACH 1	APR 74	R02A	30755
PT.BEACH 1	NOV 75	R03B	26309
PT.BEACH 1	NOV 75	R03A	26401
PT.BEACH 1	NOV 75	R03F	24961*
PT.BEACH 1	NOV 75	R03E	25041
PT.BEACH 1	NOV 75	R03D	26364
PT.BEACH 1	NOV 75	R03C	26078
PT.BEACH 1	OCT 76	R04G	34457
PT.BEACH 1	OCT 76	R04F	6571*
PT.BEACH 1	OCT 76	R04E	16664*
PT.BEACH 1	OCT 76	R04D	29703
PT.BEACH 1	OCT 76	R04C	26530
PT.BEACH 1	OCT 76	R04B	23249*
PT.BEACH 1	OCT 76	R04A	23249
PT.BEACH 1	OCT 77	R05A	33500
PT.BEACH 1	OCT 77	R05D	28480*
PT.BEACH 1	OCT 77	R05C	28502
PT.BEACH 1	OCT 77	R05B	36698
PT.BEACH 1	OCT 78	R06A	32471
PT.BEACH 1	OCT 78	R06D	37801
PT.BEACH 1	OCT 78	R06C	27250
PT.BEACH 1	OCT 78	R06B	28500

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:PT.BEACH 2			
PT.BEACH 2	APR 72	F03	37100
PT.BEACH 2	APR 72	F02	37100
PT.BEACH 2	APR 72	F01	37100
PT.BEACH 2	OCT 74	R01A	19858
PT.BEACH 2	OCT 74	R01E	21472*
PT.BEACH 2	OCT 74	R01D	21462
PT.BEACH 2	OCT 74	R01C	18908*
PT.BEACH 2	OCT 74	R01B	21357*
PT.BEACH 2	FEB 76	R02C	31855
PT.BEACH 2	FEB 76	R02B	28482*
PT.BEACH 2	FEB 76	R02A	28902
PT.BEACH 2	MAR 77	R03	36800
PT.BEACH 2	MAR 78	R04C	32300
PT.BEACH 2	MAR 78	R04B	32555
PT.BEACH 2	MAR 78	R04A	32555

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:PRAIRIE I1			
PRAIRIE I1	NOV 73	F01	31000
PRAIRIE I1	NOV 73	F03	31000
PRAIRIE I1	NOV 73	F02	31000
PRAIRIE I1	MAR 76	R01	18641
PRAIRIE I1	MAR 77	R02	29388
PRAIRIE I1	MAR 78	R03	34385

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP

***REACTOR:PRAIRIE I2

PRAIRIE I2	NOV 74	F03	31000
PRAIRIE I2	NOV 74	F02	31000
PRAIRIE I2	NOV 74	F01	31000
PRAIRIE I2	OCT 76	R01	19281
PRAIRIE I2	NOV 77	R02	28351
PRAIRIE I2	OCT 78	R03	35100

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:QUAD CIT 1			
QUAD CIT 1	MAR 74	R01	8980
QUAD CIT 1	JAN 76	R02A	16343*
QUAD CIT 1	JAN 76	R02B	16343
QUAD CIT 1	FEB 77	R03	19569
QUAD CIT 1	SEP 78	R04	21143

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:QUAD CIT 2			
QUAD CIT 2	DEC 74	R01	11450
QUAD CIT 2	OCT 75	R02	11870
QUAD CIT 2	SEP 76	R03	18158
QUAD CIT 2	JAN 78	R04C	22700
QUAD CIT 2	JAN 78	R04B	22700
QUAD CIT 2	JAN 78	R04A	22700

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:RNCHO SECO			
RNCHO SECO	AUG 74	F01	28198
RNCHO SECO	AUG 74	F03	28198
RNCHO SECO	AUG 74	F02	28198
RNCHO SECO	AUG 77	R01B	16256*
RNCHO SECO	AUG 77	R01A	16256
RNCHO SECO	OCT 78	R02B	26037*
RNCHO SECO	OCT 78	R02A	26037
RNCHO SECO	OCT 78	R02C	31663

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:ROBINSON 2			
ROBINSON 2	AUG 70	F01	30075
ROBINSON 2	AUG 70	F03	30075
ROBINSON 2	AUG 70	F02	30075
ROBINSON 2	MAR 73	R01	15859
ROBINSON 2	MAY 74	R02A	26711
ROBINSON 2	MAY 74	R02B	23512
ROBINSON 2	OCT 75	R03A	23394
ROBINSON 2	OCT 75	R03B	21550
ROBINSON 2	NOV 76	R04A	30010
ROBINSON 2	NOV 76	R04B	22909
ROBINSON 2	JAN 78	R05A	29620
ROBINSON 2	JAN 78	R05B	21000

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:ST.LUCIE-1			
ST.LUCIE-1	FEB 76	F03	26170
ST.LUCIE-1	FEB 76	F02	26170
ST.LUCIE-1	FEB 76	F01	26170
ST.LUCIE-1	MAR 78	R01	9579*

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:SALEM 1			
SALEM 1	SEP 78	R01	18175

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:SALEM 2			
SALEM 2	DEC 78	F03	33700
SALEM 2	DEC 78	F02	33700
SALEM 2	DEC 78	F01	33700

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:SAN ONOFE1			
SAN ONOFE1	OCT 70	R01A	18080
SAN ONOFE1	OCT 70	R01B	21483*
SAN ONOFE1	DEC 71	R02A	24000
SAN ONOFE1	DEC 71	R02C	22200
SAN ONOFE1	DEC 71	R02B	25006
SAN ONOFE1	JUN 73	R03C	24000
SAN ONOFE1	JUN 73	R03B	30148
SAN ONOFE1	JUN 73	R03A	24000
SAN ONOFE1	MAR 75	R04A	29817
SAN ONOFE1	MAR 75	R04B	34533
SAN ONOFE1	SEP 76	R05	33013
SAN ONOFE1	SEP 78	R06	43024

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:SURRY-1			
SURRY-1	JUN 72	F01	28000
SURRY-1	JUN 72	F03	28000
SURRY-1	JUN 72	F02	28000
SURRY-1	OCT 74	R01B	15400*
SURRY-1	OCT 74	R01A	13600*
SURRY-1	OCT 74	R01F	15500
SURRY-1	OCT 74	R01E	15300
SURRY-1	OCT 74	R01D	15400
SURRY-1	OCT 74	R01C	15400*
SURRY-1	OCT 75	R02C	20800
SURRY-1	OCT 75	R02B	11000*
SURRY-1	OCT 75	R02A	23800
SURRY-1	OCT 76	R03A	20800
SURRY-1	OCT 76	R03E	12504
SURRY-1	OCT 76	R03D	25000
SURRY-1	OCT 76	R03C	20800
SURRY-1	OCT 76	R03B	20433
SURRY-1	APR 78	R04D	26200
SURRY-1	APR 78	R04C	18000
SURRY-1	APR 78	R04B	18000
SURRY-1	APR 78	R04A	20800

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:SURRY-2			
SURRY-2	APR 75	R01A	16480
SURRY-2	APR 75	R01C	14320*
SURRY-2	APR 75	R01B	16480*
SURRY-2	APR 76	R02D	7310
SURRY-2	APR 76	R02C	7310*
SURRY-2	APR 76	R02B	20920
SURRY-2	APR 76	R02A	22900
SURRY-2	APR 76	R02E	21170
SURRY-2	SEP 77	R03A	13387
SURRY-2	SEP 77	R03C	18000
SURRY-2	SEP 77	R03B	22735

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP

***REACTOR:3 MILE IS1

3 MILE IS1	FEB 76	R01C	15800*
3 MILE IS1	FEB 76	R01B	15800*
3 MILE IS1	FEB 76	R01A	15800*
3 MILE IS1	MAR 77	R02A	24000
3 MILE IS1	MAR 77	R02B	24000
3 MILE IS1	MAR 78	R03A	28693
3 MILE IS1	MAR 78	R03B	23847

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:TROJAN			
TROJAN	MAY 78	R01	16000

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SURVEY OF THE CURRENT STATUS OF THE LWR AND PROJECTED IMPROVEME--ETC(U)
DEC 78 S E TURNER, K D KIRBY, R P HANCOCK AC8NC109
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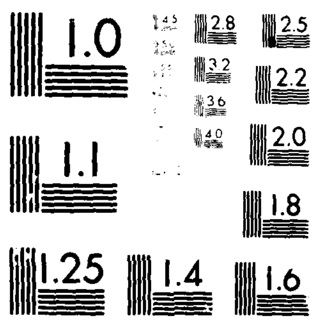

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:TURKEY PT3			
TURKEY PT3	OCT 74	R01B	14788*
TURKEY PT3	OCT 74	R01A	14788
TURKEY PT3	OCT 75	R02A	25571
TURKEY PT3	OCT 75	R02B	24355*
TURKEY PT3	NOV 76	R03A	20923
TURKEY PT3	NOV 76	R03C	28181
TURKEY PT3	NOV 76	R03B	20573
TURKEY PT3	NOV 77	R04B	20400
TURKEY PT3	NOV 77	R04A	25000
TURKEY PT3	NOV 77	R04C	29000
TURKEY PT3	NOV 78	R05A	25901
TURKEY PT3	NOV 78	R05B	29159

FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:TURKEY PT4			
TURKEY PT4	MAR 75	R01A	16689
TURKEY PT4	MAR 75	R01C	21300
TURKEY PT4	MAR 75	R01B	16689
TURKEY PT4	APR 76	R02B	23200*
TURKEY PT4	APR 76	R02A	21521
TURKEY PT4	APR 76	R02D	25984
TURKEY PT4	APR 76	R02C	23777
TURKEY PT4	APR 77	R03B	25000
TURKEY PT4	APR 77	R03A	20700
TURKEY PT4	APR 77	R03D	25750
TURKEY PT4	APR 77	R03C	27700*
TURKEY PT4	JUL 78	R04B	33659
TURKEY PT4	JUL 78	R04A	31001
TURKEY PT4	JUL 78	R04D	31000
TURKEY PT4	JUL 78	R04C	23900

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:VT. YANKEE			
VT. YANKEE	JAN 73	R01	1000
VT. YANKEE	SEP 73	R02	4367
VT. YANKEE	NOV 74	R03A	6667
VT. YANKEE	NOV 74	R03B	9187
VT. YANKEE	JUN 76	R04A	20947
VT. YANKEE	JUN 76	R04B	12645
VT. YANKEE	AUG 77	R05	17670
VT. YANKEE	JUL 78	R06	21265

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:YANKEE 1			
YANKEE 1	MAY 62	R01	8470
YANKEE 1	SEP 63	R02A	9667
YANKEE 1	SEP 63	R02C	19333 *
YANKEE 1	SEP 63	R02B	19333
YANKEE 1	AUG 64	R03B	13077
YANKEE 1	AUG 64	R03A	6538
YANKEE 1	AUG 65	R04B	16720
YANKEE 1	AUG 65	R04A	25080
YANKEE 1	AUG 65	R04D	16720
YANKEE 1	AUG 65	R04C	8360
YANKEE 1	OCT 66	R05B	16784
YANKEE 1	OCT 66	R05A	8392
YANKEE 1	OCT 66	R05C	25176
YANKEE 1	MAR 68	R06A	21330
YANKEE 1	MAR 68	R06B	31995
YANKEE 1	AUG 69	R07A	12141
YANKEE 1	AUG 69	R07C	36423
YANKEE 1	AUG 69	R07B	24282
YANKEE 1	OCT 70	R08B	31304
YANKEE 1	OCT 70	R08A	20869
YANKEE 1	FEB 72	R09B	33926
YANKEE 1	FEB 72	R09A	22617
YANKEE 1	MAY 74	R10B	37000
YANKEE 1	MAY 74	R10A	24667
YANKEE 1	OCT 75	R11B	36110
YANKEE 1	OCT 75	R11A	23874
YANKEE 1	JUN 77	R12	28285
YANKEE 1	NOV 78	R13	32771

*FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
**REACTOR:ZION 1			
ZION 1	FEB 76	R01	23330
ZION 1	SEP 77	R02B	28000
ZION 1	SEP 77	R02A	30500
ZION 1	SEP 78	R03B	34359
ZION 1	SEP 78	R03A	37190

FUEL-TRAC REPORT SORTED BY REACTOR/DISCHARGE DATE

REACTOR NAME	DISCHARGE DATE	BATCH NAME	DISCHARGE BURNUP
***REACTOR:ZION 2			
ZION 2	JAN 77	R01A	24901
ZION 2	JAN 77	R01B	27028
ZION 2	FEB 78	R02A	24100
ZION 2	FEB 78	R02B	30500